A QUARTERLY JOURNAL OF METHODS AND INFORMATION FOR TEACHERS OF SCIENCE



# The SCIENCE COUNSELOR

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# The Science Counselor

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Volume XV June, 1952 No. 2

CONTENTS



## *In Future Numbers . . .*

Among the articles planned for publication in the near future are:

**Some Old Chinese Chemical Industries**
By Henry S. Frank, Head, Department of Chemistry, University of Pittsburgh, Pittsburgh, Pennsylvania.

•

**The Use of Fertilizers in the Garden**
By J. B. Edmond, Professor of Horticulture, Mississippi State College, State College, Mississippi.

•

**Krilium**
By Mel Hedrick, Research Department, Monsanto Chemical Company, Dayton, Ohio.

•

**Chlorophyll**
By Frank L. Mercer, Associate Professor of Biology and Pharmacognosy, St. Louis College of Pharmacy and Allied Sciences, St. Louis, Missouri.

**Human Genes**
By Sister Jeanette Obirst, O.S.B., Mt. Saint Scholastica College, Atchison, Kansas.

•

**Go Underground**
By William R. Halliday, Speleologist, Denver, Colorado.

•

**Utilizing Home and Community Resources in Elementary Science Teaching**
By Ann Hopman, Supervisor of Science, Public Schools, Fort Wayne, Indiana.

•

**Folic Acid and the Control of Anemia**
By Thomas H. Jukes, Lederle Laboratories, New York City.

•

**The Ion Exchange Principle in Industry**
By Robert Kunin, Rohm and Haas Company, Philadelphia, Pennsylvania.

# Some Recent Advances in Free Radical Chemistry

• By Francis Owen Rice, D.Sc., *(University of Liverpool)*
PROFESSOR OF CHEMISTRY, THE CATHOLIC UNIVERSITY OF AMERICA, WASHINGTON, D. C.

*Until recently, almost the only direct way to study aliphatic radicals, which exist for only a few hundredths of a second, was to combine them with metallic mirrors and examine the compounds so formed.*

*Here is a brief account of a new and improved method of examination developed by Dr. Rice. It freezes out the free radicals on a surface cooled with liquid nitrogen.*

*This valuable research tool should lead to important advances in the study of the hydrides of carbon, nitrogen and oxygen.*

●

In this paper I shall consider some short lived combinations with hydrogen of the elements carbon, nitrogen, and oxygen. As might be expected, the first of these elements, carbon, forms a very large number of such compounds, some of the simpler and more common members of which are listed:

$C_1$ $CH_3-$, $CH_2=$, $CH\equiv$
$C_2$ $CH_3CH_2-$, $CH_3CH\equiv$, $CH_2=CH-$,
$C_3$ $CH_3CH_2CH_2-$, $(CH_3)_2CH-$, $CH_2=CHCH_2-$

In contrast, the possibilities for nitrogen and oxygen hydrides are much fewer as may be seen from the following partial list for these two elements:

| | | |
|---|---|---|
| $N_1$ | $NH_2-$, | $NH=$ |
| $N_2$ | $H_2N-NH-$ | |
| $O_1$ | $OH-$ | |
| $O_2$ | $HOO-$ | |

It seems unlikely that many more radical hydrides than those listed exist for nitrogen and oxygen.

The first attempts to identify and study these simple radicals were made by chemists in the first half of the nineteenth century with the object of establishing the valency of carbon. In a typical experiment, methyl iodide or ethyl iodide was heated in a sealed glass tube with an active metal and the resulting gas was thought to be methyl or ethyl respectively. At the time, Avogadro's rule was not recognized in practice so that it was not possible to obtain the molecular weight of the gas that was thought, for example, in the case of methyl iodide, to be free methyl. Even when Avogadro's hypothesis was understood and applied, and the molecular weight was found to be double that required for methyl, it was believed that ethane and dimethyl were not identical but isomeric. It was not until 1864 when Schorlemmer published the results of his researches on the paraffin hydrocarbons that it was established that substances such as ethane and dimethyl are not isomeric but identical.

All of the early attempts to isolate trivalent or divalent carbon hydrides failed and in part are responsible for one of the cornerstones of organic chemistry—Kekule's postulate of the tetravalency of carbon. This postulate continued almost unquestioned throughout the second half of the nineteenth century and no serious doubt arose until Gomberg's discovery of triphenyl methyl caused a reopening of the whole matter. The discovery that a wide variety of aromatic free radicals could be prepared by ordinary chemical manipulation, providing suitable precautions were observed against atmospheric oxidation, raised the question as to whether aliphatic free radicals could also be prepared by suitable precautions. It appeared to the chemists of the time that the factors determining the stability of free radicals were mainly size and unsaturation. Unfortunately, however, large unsaturated aliphatic free radicals do not exist under ordinary conditions any more than do methyl and ethyl.

In 1929, Paneth and Hofeditz reported the isolation of the free methyl radical by the decomposition of tetramethyl lead. They were enabled to identify and study the methyl radical by a curious property which it possesses in common with most of the other hydrocarbon radicals, namely, it can combine with certain metallic mirrors to form volatile organic compounds. Under suitable condi-

*(Continued on Page 68)*

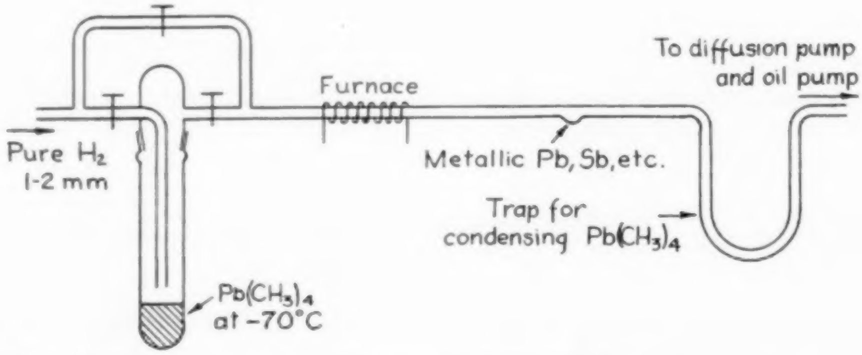


FIG. 1. Apparatus for producing free methyl radicals and demonstrating their effect on metallic mirrors.

# Causal Finality in Bacteria

• By Sister M. Petronella Schroeder, C.PP.S., Ph.D., *(Institutum Divi Thomae)*
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*This paper will be of special interest to science teachers who have studied philosophy. It correlates a scientific and a philosophical view of bacteria and their enzymatic activity.*

*The writer hopes that the data presented here will stimulate science teachers to analyze teleologically other phases of nature, thereby enriching their science courses with Thomistic philosophical interpretation.*

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The machine-like way in which bacteria can be made to respond to laboratory control has caused many microbiologists to disregard the fact that the vital activities of these organisms are directed toward a final cause. This attitude is explained partly by their philosophy of life, and partly by their method of study. Every clear thinking scientist is, whether he admits it or not, a philosophical thinker. Often what appears to be a truth discovered by science is, as Hauber says, in reality the offspring of the investigator's philosophy of life; and what would be more likely than for the man who looks upon the universe as pure physics and chemistry to consider bacteria as physico-chemical devices.

With regard to method of study, namely, experimentation, the modern microbiologist deals with only those portions of experience concerning the bacterial cell which are verifiable by observation and experiment. He traffics with only the proximate causes of phenomena, being satisfied that all changes in the activity of bacteria are caused by what is temporarily antecedent and that there is no need of looking further for an explanation. Thus, a definite stimulus results in a correspondingly definite response by the organism. Numerous examples of apparently mechanical enzymatic response by bacteria would seem to corroborate this view. Whether or not any non-material element is present in the bacterium, at least as far as its unconscious activities are concerned, is not a matter of concern to him as a scientific investigator. His chief concern is to regulate the biochemical mechanisms of bacteria so that predictable results will follow. This end becomes all the more important to him since the biochemical reactions obtaining in living matter hold possibilities of much wider application economically and commercially.

Why should microbiologists having such an approach to the study of nature be awakened to a genuine interest in the final cause of these lowly bacteria, in addition to the study of the more proximate causes? Inasmuch as the activities of these organisms are of only an unconscious order, it is evident that this view is not for the sake of the bacteria. The microbiologist himself is the intended beneficiary of any such effort. Through a fuller knowledge of bacteria in their final cause, the microbiologist as a member of society will the better appreciate the design, the order, and destination, or final cause of a larger world in which bacteria form an integral part.

Of what do we wish the microbiologist to take cognizance when we say that the vital activities of bacteria are directed toward a final cause? Simply this—that bacteria, like every other living entity always seek their own good. Under the ordinary circumstances encountered in their environment they tend toward their own well-being. In other words, when any condition which tends toward the ill-being of the organism occurs, certain physical and chemical changes as demanded by the nature of the organism occur and continue until, possibly after trial and error, new equilibria are established which make for the well-being of the organism's existence.

Valuable evidence of this purposefulness in bacterial reactions may be contributed by the microbiologist in the course of his investigations on just what bacteria do and how they do it; for in answering these questions by experimentation he is collecting more information concerning the nature of these organisms, or their substantial form, to use the philosopher's vocabulary. Now, it is this substantial form that accounts for what bacteria do, or are potentially able to do.

Since most relationships of bacteria to the great outside world become known through their enzymatic activity, we might logically expect to find therein the chief means employed by bacteria in seeking their own good, that is, in attaining their final purpose. With respect to bacterial enzymes, let us recall that they themselves are not living entities but are chemical devices, originally formed by the living organism, which facilitate the carrying out of an enormous variety of chemical operations necessary for the life of the organism; that a single bacterium may contain hundreds of these enzymes each of which is present actually or potentially in the minutest quantity only, yet performs its functions specifically, effectively, and at just the proper speed for particular subsequent biochemical reactions in the chain of cellular metabolic activity. Clark pictures enzymes in the living cell as "marshalled and ordered, placed in strategic places so that they can do their work with the least possible confusion in the atomic medley."

We may now ask whether the enzymatic activity of bacteria as observed by the microbiologist has for its purpose the attainment of the good of the organism. On the basis of accumulated experimental data Gale speculates on the nature of variation in the enzymatic activity within a given organism with the idea of

*(Continued on Page 72)*

# The Study and Interpretation of Fish Scales

**• By James W. Moffett, Ph.D.,** *(University of Michigan)*
CHIEF, GREAT LAKES FISHERY INVESTIGATIONS, UNITED STATES DEPARTMENT OF THE INTERIOR, FISH AND WILDLIFE SERVICE, ANN ARBOR, MICHIGAN

*Few persons are aware of the amazing amount of valuable information that is now being derived from studies of fish scales, and of how the knowledge so gained is used in conserving our fish supply.*

*Scale readings disclose growth rate and age, and prove that a small fish is not necessarily young. Such studies help determine average longevity, suitability of various fish to a given water, the effects of growth on varying population densities, and the best rates of harvest.*

*You will enjoy this enlightening article.*

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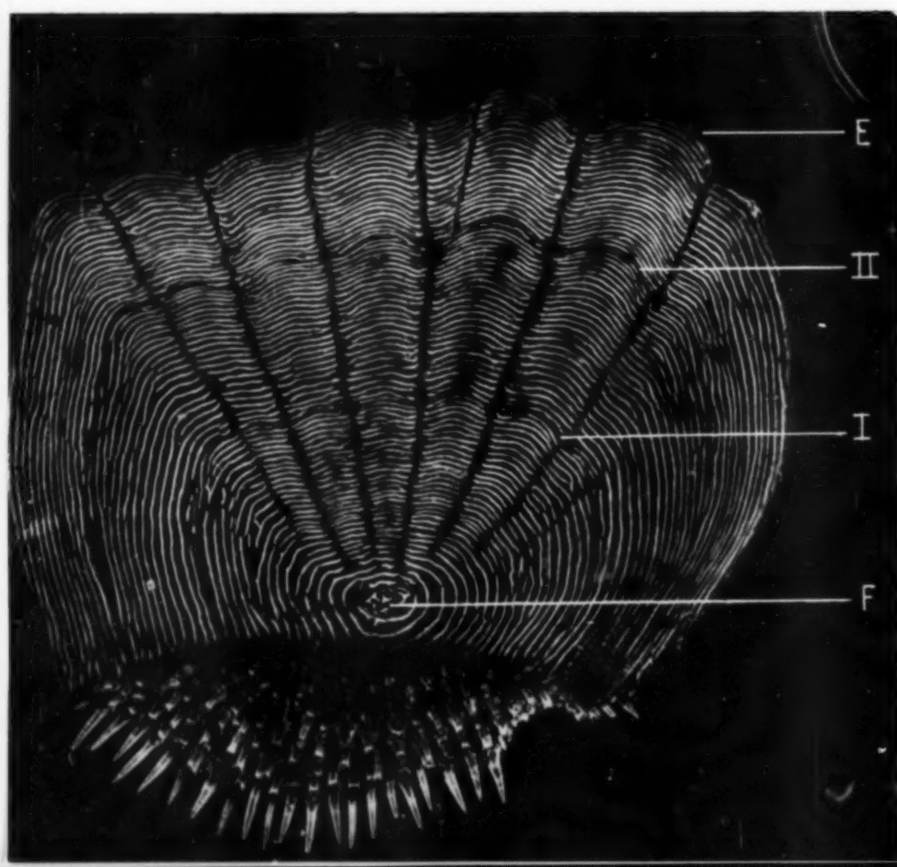
From the time of the discovery of the microscope, fish scales have been objects of study and deliberation. Leeuwenhoek, the pioneer Dutch microscopist, found and described eel scales in 1686. He conjectured from their sculpturing that the circular lines on the scales might be records of age. Réaumur, in 1718, believed that the concentric lines on scales indicated different degrees of growth.

Photomicrograph of Blue Pike Scale. Collected from Erie, Pennsylvania, October 2, 1951. 7.8 inches long. F = focus; I, first year annulus; II, second year annulus; E = edge of scale.



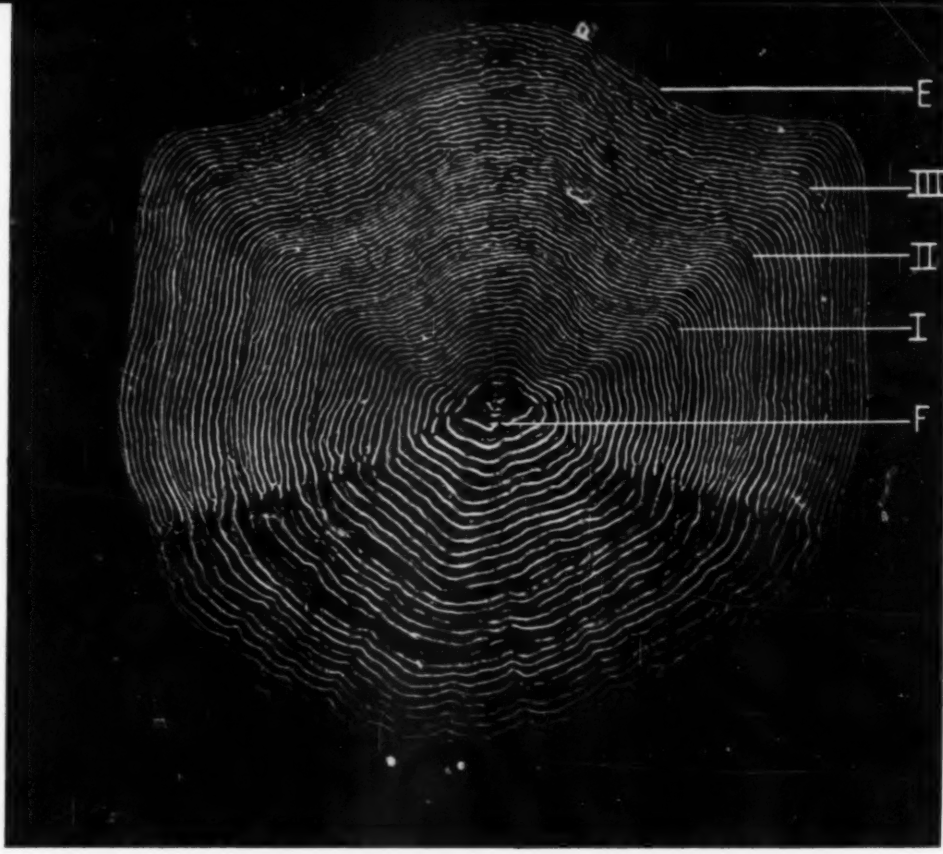

Many other investigators pondered the matter of scale sculpturing in relation to age of fishes throughout the nineteenth century, but none of them did the experimental work necessary to test the idea. Had it not been for an error in interpretation of growth zones, a German, Hintze, would have validated the scale method in 1888 from his study of the scales of carp of known ages. It remained for Hoffbauer, another German, in 1898 to test critically the scale method of age determination. Hoffbauer's findings resulted in the widespread utilization of fish scales as dependable indices of the ages of many fish species. Three years later, a German named Walter first announced the relationship between the relative length and width of a growth zone on a scale and the relative intensity of body growth. As it evolved from these basic concepts, the scale method became a useful tool in life-history studies of most of our important food fishes throughout the world.

Fishes are cold-blooded animals which live and grow at a rate controlled to a certain extent by the temperature of the water they inhabit. They also grow at a rate commensurate with, among other things, their food supply and the density of the population in which they live. Consequently, their growth is a reflection of environmental influences. Most fishes are covered with scales which are arranged in rows and which overlap each other like shingles on a roof. As a fish grows in length and girth its scales also increase in size so as to keep the fish's body covered and protected against injury. The scales grow proportionately to the length of the fish and stand in such a relationship, with minor exceptions, throughout the fish's life.

Fish scales are formed and are retained in small skin pockets. These pockets are lined with cells which produce the material composing the scale substance. If a scale is lost or knocked off, a new one is formed which consists of a clear, smooth plate approximately the size of the lost scale. This scale then resumes the normal type of growth. Scales are laid down in such a manner that concentric rings are conspicuous scale features. The relative spacing of the concentric rings reflects the rate of growth of the fish. A rapidly growing fish will form rings in its scales that are uniform and rather widely spaced. As the growth rate slows down, these concentric rings are much closer together and when

growth practically ceases, as it does in winter, the rings are incomplete, rough and closely appressed. It is the line of discontinuity between such 'winter marks' on the scales and the pattern formed when more rapid growth is resumed in the spring, that indicates a fish's anniversary. Typical annuli are shown on the accompanying photomicrographs of scales. By counting the number of these "winter marks" or annuli, the age of a fish can be determined.

We have noted that in most fish the scales grow approximately in proportion to the body. It follows then, that given the length of a fish at the time it is caught and the distance from the center (focus) of a scale to its border and the distance from the focus to each "winter mark," the length of the fish at any or all anniversaries during its lifetime can be calculated. This basic fact is of great importance in the study and management of fish populations.



PHOTOMICROGRAPH OF LAKE HERRING. Collected from Green Bay, Lake Michigan, August 20, 1951. 8.3 inches long. F = focus; I first year annulus; II second year annulus; III third year annulus; E = edge of scale.

The question has undoubtedly come to mind regarding the problem of age determination in fishes which have no scales. Many fishes, scaled and scaleless, show "winter marks" or recognizable annular rings in their bones. Favorite bone structures preferred for age determination are ear stones (otoliths), vertebrae, gill-cover bones, and fin spines. Bone structures are usually cut into thin sections and examined microscopically for the characteristic annular marks. Such studies are often conducted as a partial check on the validity of the scale method of age determination when it has not been validated previously for the kind of fish under study.

Fish scales were usually mounted in a suitable medium on microscope slides and studied with the standard microscope. All measurements were made with mechanical stages and ocular micrometers. The processing of thousands of scale samples in this manner was a time-consuming and tedious process.

Early in the history of such investigations, enterprising students of the scale method strove for and developed changes in the technique of reading scales. Several models of scale projectors were developed but most of them used the microscope and prisms or camera lucida. The direct projection of scale images progressed through several stages which started with the microscope as the basic tool for magnification. Drs. John Van Oosten, Hilary J. Deason, Frank W. Jobes and Ralph Hile of the United States Fish and Wildlife Service developed a projector using microtessar lenses and standard projection equipment. This instrument went through a number of models which featured direct lineal projection onto a ground glass screen, but all of them proved to be inconvenient and cumbersome to use. Finally, a mirror was introduced into the projected beam which reflected the image onto a screen placed at such an angle that the operator could sit at the machine and read images rapidly and comfortably. Remote control attachments brought all focusing adjustments within easy reach of the operator. Refinements in design ultimately resulted in the latest model projector shown in the accompanying photograph. The ground glass screen has been replaced by a piece of rubber dental dam mounted between two sheets of glass. This surface gives a much truer image and does not reduce the quality of the image at high magnifications. The improved screen also provides a smooth glass surface upon which marks with glass-marking pencils can be made as an aid in diagnosis and then easily erased.

The most recent development in the scale method was made in the processing of scales for reading. Instead of mounting the scales directly on microscope slides, plastic impressions of the scale sculpturing were made. This process accelerated the preparation of specimens and also made for better interpretation especially where scales were thick enough to prevent passage of sufficient light through them to give a clear image of the sculpturing.

Several models of presses to make the impressions were evolved and the developmental phase of this work is still going on. Hydraulic jacks were adapted to press the pattern of scale sculpturing into plastic sheets of various kinds. These presses sometimes included heating plates which softened the plastic. Jeweler's presses or rollers were also used to furnish the pressure necessary to make the scale impression. No one method of making impressions is standard, as

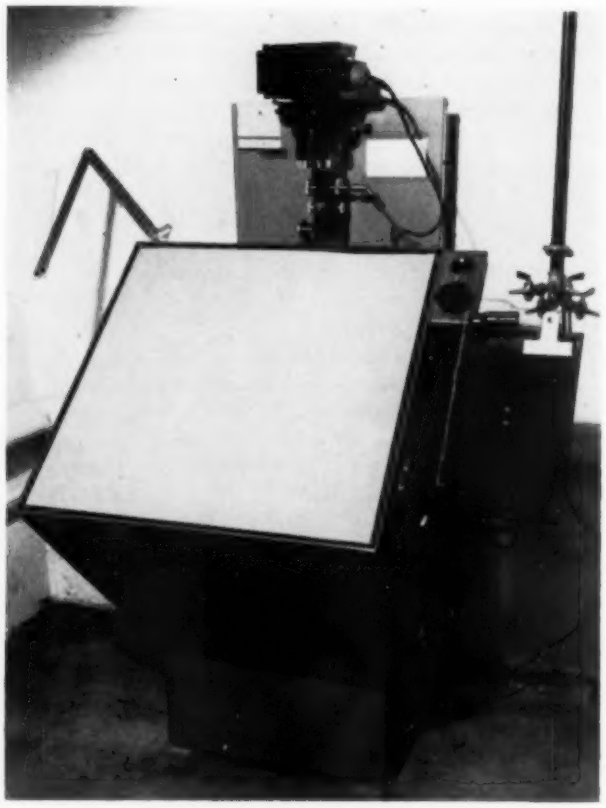
yet, since each has shown merits and disadvantages. Some methods are better adapted to making impressions of scales of certain species of fish while others give the best results with scales of different species.

Some experimentation has been done to learn the various kinds of plastic best suited to the making of scale impressions. All of the many kinds of plastic have not been tested but, currently, cellulose acetate appears to be well adapted and is widely used for this purpose.

Knowledge of the growth rate and age composition of a population of fishes is essential if the best use of that population (conservation in its true sense) is to be realized. From adequate scale studies the following points of information, among others, can be determined or partially explained: (1) the best rates of harvest, (2) the relative success of survival in various years, (3) the effects on growth of varying population densities, (4) the rate of population replacement in a given water, (5) the suitability of various fish species to a given water, (6) the average longevity of a species, and (7) the reasons for the occurence of dominant year classes in populations.

Some of the results of growth studies based on scale readings have changed materially the thinking and policies underlying the management of fishery resources. It is now widely recognized that small fish are not necessarily young fish. Many lakes and ponds full of little bluegill sunfishes and undersized black bass were protected carefully so the little fish would grow. Size limits and other legal restrictions on fishing were designed to insure that these little fellows would get bigger if left in the lake. But they didn't grow larger except very slowly. Studies of scales from these little fish proved them to be old and mature. Their chances of growing big were slight because they would die of old age before they made such growth. By chance, or accident (usually winter kill), populations in some of these lakes were reduced materially and scales from survivors of these catastrophes showed a much faster growth rate. The idea of thinning or eliminating "stunted" populations of this sort was a natural result of these observations. Now, in management of many such waters restrictions have been removed. Fishermen are encouraged to catch all they can take. No protection is afforded the fish even during spawning time and artificial stocking has been stopped. In certain stubborn cases the whole fish population is deliberately poisoned and a new stock is introduced. The new idea of keeping the fish stock down to the level of its food supply to put bigger fish in the frying pan in the shortest period of time had its birth in the scale method of age and growth determination. The condition of such fish populations can be followed constantly by means of scale analyses and the "take" can be adjusted easily to keep conditions in balance for maximum production.

This example is just one of many that could be cited to illustrate the value of age and growth studies from scale analyses. There is no substitute for direct knowledge of age and growth in the management of any crop of animals whether they are fish, beef cattle, or sheep. The discovery of the relationship of sculpturing and size of a fish's scales to its age and growth is probably the most significant contribution made to the present time in the field of fishery biology. ●



Fish Scale Projection Machine.

"Let the child of low intelligence and weak natural endowments be represented by a pint container, and the child of extremely high endowments and intelligence, by a gallon container. According to the democratic concept of education, you must put into the pint container whatever kind of liquid you put into the gallon container, even though only one pint can go here and a gallon there. It will not do to put cream into the gallon container and, say, water—dirty water, at that—into the pint container. Vocational education is the dirty water we are now pouring into our pint containers. Liberal education is the cream we are giving the few."

—MORTIMER J. ADLER
*Journal of Higher Education*

# The Contributions of Belgians to Chemistry

• **By Milton Mager, M.S.,** *(Rensselaer Polytechnic Institute)* AND

**Fabian Lionetti, Ph.D.,** *(Rensselaer Polytechnic Institute)*

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*This article performs a service in directing attention to the creativeness of Belgian scientists and to the important theoretical and practical contributions they have made to chemistry. These include the study of atomic weights, the elucidation of the structure of organic compounds, and the refinement of quantitative procedures. Industrial advances are evidenced in the soda and plastics industries.*

*Among the workers mentioned in this paper are Van Helmont, Stas, Kékulé, Solvay, Sauveur, Baekeland, and Father Nieuwland.*

●

Great men and universities have always worked jointly to advance the frontiers of science. In Belgium the effect of both influences was retarded or rendered inoperative because of a turbulent political history until the year 1830. A period of oppression by surrounding powers was a yoke upon the creative efforts of the nation until complete independence was established. It is perhaps of significance to consider briefly then the historical development of its universities, which advanced rapidly following the unification of the people.

Prior to 1830 there is recorded the history of the Royal Academy which was founded in 1769, after which an indefinite period of inactivity followed, probably influenced by military exigencies and economic factors. A revival occurred in 1818, after which keenly contested prizes were awarded in literature and science. With the feeling of nationalism which prevailed thereafter four large universities were founded, in addition to several smaller ones, nearly all of which were inaugurated within a decade of one another. It is notable that a "renaissance" of this magnitude transpired in a nation whose present population is comparable with that of the city of New York.

The oldest and largest of Belgian universities was the Catholic University at Louvain[1], founded in 1425 by John the IV, Duke of Brabant. It was composed of twenty-eight colleges and for some time enjoyed a reputation as one of the greatest strongholds of learning in Europe. After 1788 the university was destroyed by political and economic strife, but when Belgium gained its independence from Holland the new University of Louvain was formed at Malines, and in 1834 was moved to Louvain. The number of students enrolled in 1939 was approximately 4,270.

Another of the more important schools was the University of Brussels, founded by the Liberal party in 1834 after the destruction of the old University of Louvain. In 1939 it was composed of five faculties and had about three thousand students. It has its own publication entitled *Revue de l'Université Libre de Bruxelles.* Two somewhat older schools with smaller student bodies are the Universities of Ghent and Liege, both of which were founded in 1817, and both of which are maintained by the state. The former was founded by King William the I of Holland, while the latter was originally a college of Jesuits.

Although but two or three Belgians have their biographies in the world literature on the history of chemistry, numerous others deserve recognition. Jan Baptista Van Helmont is chronologically the first Belgian usually noted, and in some works is given considerable attention, especially by J. R. Partington[2]. Here a significant amount of space is devoted to Van Helmont's contributions to chemistry, perhaps because his work tied in with that of the early chemists on the study of gases. He was a physician who showed a capacity for accurate observation and clear thinking in his work. During his lifetime (1577-1644), he worked extensively with carbon dioxide and uncovered much original information on its modes of formation from fermented juices, from the pyrolysis of wood, and from the action of acids on limestone. He was able to demonstrate its lack of support of combustion and was the originator of the word, "gas." It is ironical that this substance which he is credited with having discovered proved to be his experimental nemesis in the lengthy and well-known experiment in which he investigated factors which influenced the growth of a willow tree[3]. After observations for five years on the weight changes in the young tree, Van Helmont made his classic conclusion that water added during the plant's growth was the only nutritional substance on which all vegetation depended. This led to his adoption of water as the fundamental basis of matter. Although his deductions were unfounded in part, his work shows perhaps the earliest recorded investigation of photosynthesis and represented a good scientific investigation for those times. In fact, the reasoning was consistent in many respects with the interpretation of much present day data. Van Helmont's other outstanding contributions were studies on the nature of fire which he believed to be a manifestation of an intensely heated gas, and in medicine where he classified diseases as acid or alkaline and treated them by neutralization. He was among the first to attempt a systematic analysis of urine.

Following Van Helmont a long pause historically is seen until another luminary appeared in the person of Jean Servais Stas. Before considering this perhaps most eminent of the early Belgians, one could recount briefly the work of Jean Baptiste Van Mons and Jean Pierre Minkelers, who are perhaps the only men deserving of mention in a rather sparse literature during this interval. Van Mons was born in 1765 in Brussels,

and died in 1842 at Louvain. After studying pharmacy at Brussels, he became professor of chemistry and physics at Louvain, where he remained from 1817 to 1830. There are recorded up to 1839, three years before his death, a total of eighty-two publications which appeared tabulated mainly in the *Catalog of Scientific Papers of the Royal Society of London.* A great deal of his work was on pharmaceuticals, such as, the chemistry of ointments, mercury and antimony salts, ethers, and on materia medica. His theoretical work included the philosophy of chemistry, the electrical phenomena studied by Franklin, and theories of combustion and explosives. It is significant that his work was of a diverse nature and included, as well, researches on the Davy theory of reduction of alkali metal salts.

**TABLE 1**

| | |
|---|---|
| Jan Baptista Van Helmont | (1577-1644) |
| Jean-Pierre Minkelers | (1748-1824) |
| Jean Baptiste Van Mons | (1765-1842) |
| Jean Servais Stas | (1813-1891) |
| Louis Melsens | (1814-1886) |
| Friedrich August Kékulé | (1829-1896) |
| Louis Henry | (1834-1913) |
| Ernest Solvay | (1838-1922) |
| Walter Spring | (1848-1911) |
| Léon Crismer | (1858-1944) |
| Frederic Swarts | (1866-1940) |
| Albert Sauveur | (1863-1939) |
| Leo Hendrick Baekeland | (1863-1944) |
| Julius Arthur Nieuwland | (1878-1936) |
| Jean Timmermans | (1882- ) |

Minkelers[4], (1748-1824), born in Maestricht, was professor of natural philosophies at Louvain. He is known for his published memoirs (1784) "on inflammable air" in which he demonstrated the combustion of coal gas by burning coal dust in a rifle barrel. His recorded work includes also some meteorologic data and geological studies of the mountains near Maestricht, being credited with one of the first discoveries of saurian fossils there.

It is generally agreed the individual whose achievements ranked among the foremost of all 19th century Belgians was Jean Servais Stas[5, 6]. In addition to researches which brought him widespread recognition, the influence he exercised over his students and contemporaries, and the lineage of prominent chemists which he "sired" was in itself a contribution of note. Stas was born in Louvain in 1813. He studied medicine at the University there and was graduated in 1835. Although interested in physiological studies, his interest in chemistry was inspired by Van Mons, an early disciple of Lavoisier, who taught him chemical manipulations. He entered Dumas' laboratory in Paris, at Van Mons' suggestion, with the aim to devote himself to the chemistry of organic substances. Throughout his lifetime of active work his background in medicine and biology is shown by such things as the development of toxicological tests, the discovery of phloridzin, and the determination of vegetable alkaloids.

In 1841, Stas became professor of chemistry at the Military School in Brussels where his most famous work, the study of atomic weights, was conducted during the ensuing twenty-five years. Stas became interested in the determinations of atomic weights through the influence of Dumas with whom he worked on the oxygen-hydrogen ratio in water. Their value of O:H = 840.161 : 105.278, that is, 16.0000 : 2.0050, was accepted until 1888. He also collaborated with Dumas in the determination of the atomic weight of carbon. This led to a lifelong project in the extension and refinement of the methods of quantitative analysis applied to atomic weight methods in an attempt to investigate the Prout hypothesis that all atoms had masses which were integral multiples of the hydrogen atom mass of 1.00 unit.

Moore says of Stas: "He refined the processes of quantitative transformation to a degree never before equalled, working with highly purified materials, employing exceptional weights of substance, making his weighings on balances of hitherto unequaled precision, and exercising extraordinary care in his manipulations." The accurate results obtained showed, of course, non-integral values for atomic weights, which indicated that the theoretical development of science in his time had not progressed sufficiently for the acceptance of Prout's ideas. It is commonly said of Stas that his work in quantitative analysis represents the maximum in human patience.

Stas was influential in directing the efforts of some of Europe's better chemists. Through him Louis Henry, who did researches on the structure of nitriles and the equivalence of the four valences of carbon, was elected to the Belgian Academy. At his suggestion the University of Ghent employed Kékulé, who attracted students from all of Europe. His advice was decisive in the choice of profession by Walter Spring who eventually became professor of chemistry at Liège and became internationally known. Stas also secured the nomination of Houzeau, a prominent astronomer, as director of the observatory at Uccle. A throat ailment forced Stas to retire from active teaching in 1865, and he accepted a position with the Mint which he held until 1872. He lived in retirement then until he died in 1891. At the suggestion of Professor Heger, of the University of Brussels, Ernest Solvay purchased most of Stas' souvenirs which were retained by the University for exhibit in its museum. A large amount of his immense correspondence was saved for history by the present professor of physical chemistry at Brussels, Jean Timmermans. A number of contemporaries as well as several former students were prominent during the period of Stas' professional career. Among these were Louis Melsens (1814-1886), Friedrich Kékulé (1829-1896), Louis Henry (1834-1913), Ernest Solvay (1838-1922), and Walter Spring (1848-1911). A brief discussion of the accomplishments of these men is herewith recounted.

Louis Melsens[7] was born in Louvain in 1814, and received his Ph.D. at Giessen in 1841. In 1842, while an assistant in Dumas' laboratory, he carried out a reaction which has served to preserve his name in the history of the development of organic chemistry. During this period Berzelius greatly influenced the current beliefs on the theories of structure. He did not believe in the nucleus theory of Laurent and condemned it.

This involved the substitution of hydrogen by chlorine in radicals, an idea which Berzelius refused to accept. As a result a vigorous controversy was created in chemical circles. When Dumas prepared trichloracetic acid in support of the substitution theory, Berzelius refused to recognize its existence. However, when Melsens succeeded in reversing the substitution, and easily passed back from the chlorinated compound to acetic acid by reduction with nascent hydrogen, Berzelius had to take refuge in a new formula for acetic acid. For most of his professional career, Melsens was professor of physics and chemistry at the State School of Veterinary Medicine in Brussels. A great deal of his work was devoted to the study of albumin, chloracetic acids, and natural products, for instance, wood and urine. In physics his investigations were conducted on the nature of metals, the production of galvanic electricity in batteries, and the liquefaction of gases. He died in Brussels in 1886.

Friedrich August Kékulé[8, 9], (1829-1896), was born in Darmstadt, and was, of course, not a Belgian. However it would be a gross injustice to bypass his great accomplishments on the basis of foreign birth inasmuch as a good portion of his productive life was spent as professor of chemistry at Ghent. It was here that much of the work was published for which Kékulé is accredited toward laying the foundation of modern organic chemistry. The first of these papers, which earned him world-wide recognition and secured for him the chair in chemistry at Ghent, developed the concept of atom linking. The article, *On the Constitution and Metamorphosis of Chemical Compounds, and the Chemical Nature of Carbon*, has led to our present use of constitutional formulas. During the nine fruitful years spent at Ghent, Kékulé published the text, *Lehrbuch der organischen Chemie*, which, by means of hundreds of examples, elaborated and emphasized his views on the structure of organic compounds. Here was developed his theory of the benzene molecule, (1865), for which modern students of organic chemistry probably remember him most. Obviously, this doctrine has been as important and useful as that of atom linkage. Listed among his many students at Ghent are names like Baeyer, Ladenburg, Dewar, Hubner, and Körner. In 1867, Kékulé accepted a professorship at Bonn where he remained until his death in 1896.

Louis Henry[10] was a Belgian (born in 1834) and a contemporary of Kékulé, whose achievements were similarly distinctive in the field of organic chemistry. He received his Doctor of Science in 1834, and later became professor of chemistry at the University of Louvain. He published widely (in about fifteen journals) on reactions and theory of organic chemistry and contributed more than 150 publications. The main theme of his studies seems to centralize around the study of alcohols, their reactions, volatilities, and comparative properties. He is credited also with extensive work on halogens, halogen acids, organic halogen derivatives and the theory of atoms. An appreciable amount was done on nitriles, in which field he was the first to prepare cyclopropane carbonitrile. Perhaps one of his greatest contributions was the propagation of the high standards initiated by Stas, being the sponsor of several men prominent in modern Belgian chemistry; namely, R. Breckpot and G. Bruylants. His productive career ended with his death in 1913.

Ernest Solvay[11] (1838-1922) was the chemist whose well-known process for the economical production of sodium carbonate replaced the older, more expensive Le Blanc method. Prior to its development, there had been numerous unsuccessful attempts for the large scale reaction of sodium chloride with ammonium bicarbonate. Solvay successfully developed the process and proved that sodium carbonate could be made purer and more economically than by the older method. He is reputed to have spent a good portion of his financial gains in the founding of educational facilities in Belgium.

Walter Spring[12], (1848-1911), was one whose feats were a good deal more academic than those of Solvay. He received his Ph.D. at Liège in 1872, and then studied at Bonn from 1873 to 1874. Among the positions held during his lifetime were those of professor of organic chemistry at Liège, and engineer at the Belgian Bureau of Mines. His numerous and varied investigations showed him to be quite versatile and to have interests broad in scope. He is remembered mainly, however, for the study of the effect of pressure on liquid systems and for researches in colloids wherein he dealt with the formation of arsenic sulfides, absorption by them of barium ions, and a proof that a sharp optimum existed for emulsification which was a function of concentration. He did much to help prove that gravitational, electrical, magnetic, and surface tension forces between particles were not the causes of the Brownian movement. Other work in physical chemistry included a study of capillary phenomena, heat capacities, and compression of powdered solids, (published in Silliman's journal, the first scientific journal in the United States). He published jointly with van't Hoff and also in Ostwald's journal. Numerous other labors can be listed among as varied fields as crystallography, pharmacy, organic chemistry, physics, and geography. It might be of interest to note that he did some work on the analysis of water of the Meuse river, the cause for the green coloration in thick layers of water, on the density of the earth, and on the origin of the blue color of the sky. Most scientists are kept quite busy in one category of endeavor and are usually content in being regarded as authorities in some one aspect of science. Walter Spring's versatility, in addition to his achieved recognition, is in itself a tribute to his greatness.

Léon Crismer[13], a contemporary of Spring, was born in 1858 in Stavelot. After extensive study, which included four years (1875-79) in pharmacy at the University of Liège, and three years (1879-82) in chemistry at Strassburg and at Bonn, he became professor of chemistry at the Military School in Brussels. Much of his work was devoted to the investigations of reaction mechanisms of organic chemistry, and methods of inorganic analysis. He investigated the Perkin reaction, collaborated with Claisen, and studied hydroxylamine with reference to its derivatives and combination with metal chlorides. His analytical studies covered the

*(Continued on Page 74)*

# Along the John Muir Trail

• By Joseph Carson Wampler
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*Traveling the John Muir Trail through the high Sierras is an unforgettable experience that gives rich reward to the student of nature and history and to the seeker after adventure and experience.*

*Winding along some 200 miles between Mt. Whitney and Yosemite National Park at elevations ranging from 8,000 to 12,000 feet, the trail is not crossed by a single road. It was planned deliberately to make the region only moderately accessible, so that those who discover the beauty of this comparative wilderness will insist upon its preservation.*

*You will enjoy this account written by one who knows the Trail well.*

The mornings were especially sparkling in the spring of 1884. One such day, a boy of fourteen sat on an unsaddled bronco in a large unfenced alfalfa field just outside of Fresno, California, herding his uncle's cattle. While they were quietly feeding, he faced the east, and as boys will, sat dreaming. His dreams were about the Sierra Nevada, whose western slope rose gradually from the valley floor to the snow-capped crest eighty miles away. This rugged, peak-studded crest could be seen stretching for miles, roughly north and south. This boy could see himself, "in the immensity of that uplifted world, an atom moving along just below the white, crawling from one end to the other of that horizon of high enchantment."* He made up his mind that somehow soon he would make that journey. The dreamer's name was Theodore Solomons, and the dream has been recognized as the beginning of the north-south trail now named for John Muir.

For this boy, like many another, was not just content to dream. He worked hard to make it a reality. After four years of working and saving, he and a companion made a first try which was not successful. So he went to Muir for more accurate and detailed information. Another try was made and then a third before winning a way through the high mountain country from north to south. But this was just the beginning, and many years passed before the John Muir Trail was completed.

When John Muir came to California in 1868, the Sierra Nevada was completely wild throughout much of the higher part. There were several east-west trails used by the Indians, herders, and miners. They also moved north and south from these trails into the more accessible high country. But it remained for men like Muir to travel into the more inaccessible regions. Here he roamed and sauntered, climbed and scrambled for many years in all seasons, and he saw and felt many fine things which he has passed on to us in his writings.

He was not, however, the first to travel and work in many parts of this country. There were very able mountaineers and eloquent spokesmen before him as well as afterward. Muir, however, roamed farther and longer, saw more and felt more, and was most eloquent in his expression. Hence, it is only fitting that the north-south trail which traverses the high Sierra should be called the John Muir Trail.

FIGURE 1. Mt. Whitney, highest peak in the United States, from Big Horn Plateau.

Some might ask, why build a trail? Why not leave the wilderness completely wild? It is highly desirable that we have such country as part of our national resources. Yet this particular region was threatened by small interests from early times. It is fortunate for us that Muir recognized this threat at an early stage. His idea was to make the region moderately accessible as a means of preserving it as comparative wilderness. This may seem paradoxical, but it it has proven very practical. Let the people come and see and they will want to hold fast to the good. And this is possible, if the way is marked out and moderately smoothed, just a trail.

It was done this way. Over a period of years sections of the trail were built. How it was accomplished is a fascinating story

* Sierra Club Bulletin, Feb. 1940, vol. 25, No. 1, p. 28.

which requires considerable space in the telling. Briefly, many had a share in this complex project. There were individuals, clubs, private organizations, state and federal agencies—truly a democratic achievement.

An important part of this story must be told since it bears both upon the construction and the naming of the trail. In the summer of 1914 the Sierra Club voted to seek appropriations from the State of California to aid in the construction work. While plans were being formulated, John Muir, the beloved president of the Sierra Club, died. What could be a fitting memorial to this man who had done so much to explore and make known the beauties of the high Sierra? It was decided to name the crest trail for him. The first appropriation bills, introduced into the 1915 California Legislature for this project, specifically referred to it as the John Muir Trail, and subsequent usage made the name official.

FIGURE 2. Morning light on Mt. Clarence King.

Twenty-two more years passed, however, before the task was finished, for the last link over Mather Pass was not completed until 1937. The building of the trail presented many engineering problems as well as financial ones.

The total length is about 200 miles; over 160 miles of this lies between 8,000 and 12,000 feet of elevation. The southern terminus is near Mt. Whitney, the highest peak in the United States; the north end is in Yosemite National Park. Twelve peaks along the route tower more than 14,000 feet above sea level, while there are 148 peaks reaching above 13,000 feet. These figures suggest how challenging this country is. They give but the barest inkling of its grandeur.

A notable feature of this trail is the fact that it is not crossed by a road; it is our eternal loss that such cannot be said about another wilderness area of this country which is of equal extent. True, it is touched by a road. And touched means to violate. There is an experience which seems common to all who have set their feet on the high places of the mountains, whether it is the first time or the hundredth time. A road into a wilderness is a desecration; motor dust and fumes are an abomination. Biblical language may seem strong, but so is your reaction.

This is in no sense a criticism of the Park and Forest Services. It happens that the Muir Trail is entirely within areas administered by them, for it passes through portions of Sequoia and Kings Canyon National Parks and Inyo and Sierra National Forests. Good administration, however, cannot obliterate the harmful effects of roads in the wilderness; it can only ameliorate them. If the people demand more roads, good administration can be expected. The thing to do, however, is to get more people to understand the major values of wilderness areas and to protect them accordingly.

This brings us back to Muir's idea that the way to conserve the wilderness as such is to make it moderately accessible, and show it to the people. He has taught us well. He taught us that here as well as in similar areas elsewhere there are things more precious than silver and gold, more necessary than mutton and wood. But the smaller interests are still a threat—the interests of mutton and wood, silver and gold—and more crusaders, as it were, are needed to guard against them.

Since 1937 and the completion of the John Muir Trail a relatively easy pilgrimage throughout the length of this region has been possible. The way has been marked out and smoothed, a good mountain trail. You don't have to be a Muir, a King, a Le Conte, or a Colby to traverse it. Every year people now come from all parts of the country to set their feet on the high places.

Ours was just such a party. Some walked and others rode horseback, the proportion of walkers to riders being two to one. A few extra saddle horses were taken so that some could ride occasionally. Then there were mules to carry the personal dunnage of each individual, as well as food and general camp equipment.

There were professional packers who cared for the animals and packed the mules. Also there was a commissary group which assumed major responsibility for the trip management. Everyone, however, was given a chance to share these responsibilities as well as minor chores, for is there anything more dull than a "dude trip?"

The entire Muir Trail was traversed in 28 days. Some came for four weeks and went all the way. Others came for one or more weeks and covered a part of it, reserving the remainder for another season. This is possible, since the schedule is divided into sections of a week each. At these division points, some people

left our party while others came in to join the main group which remained at a campsite on the Muir Trail.

Fresh supplies were brought in at these times too. Being supplied at such frequent intervals made possible a diet not unlike that which we eat at home.

People came from all parts of the country—New York, New England, the South and Middle West as well as the Pacific Coast. Some came alone, others with friends or a family group. The oldest was seventy, the youngest, thus far, eight and a half. Many different professions and interests were represented, but all were united in the common interest, the high Sierra.

FIGURE 3. Looking south from Mather Pass across the Upper Basin to Mt. Pinchot. This mountain was named for Gifford Pinchot, former Governor of Pennsylvania.

It is natural that a number of teachers should come because of the wonderful opportunity for field observation. The lowest point along the trail is about 7,500 feet, while the highest is 14,496 feet. Hence it passes through portions of the Transitional, Canadian, Hudsonian, and Arctic Life Zones (Merriam) with their characteristic flora and fauna. In recognition of these interests, whether professional or casual, a sizable portion of the commissary staff was drawn from graduate students in the natural sciences. These gave expert assistance during camp fire programs or at other times when requested.

Although the educational aspect of the program was always available, it was not inflicted upon the group. Some did not wish it, others did, and we acted accordingly.

It is important to approach the mountains in the spirit of the poet or philosopher as well as that of the scientist. How rewarding is the experience of one who takes the trail early with a quiet companion or two! They see the delicate hues of the morning sky, startle the doe from her dewy bed, hear the thrush in liquid song, and being abroad before the wind, have distant view multiplied by a nearby lake in mirror calm. Even though you do not come as a poet, a philosopher, or scientist you should at least make a journey to see how it goes with your mountain estates, lest through neglect you lose a precious heritage and they pass to coarser hands.

Now this is a journey not only to the high places of the country but to the high places of life. The way is the crest trail of the western mountains. It is rich in opportunities for the student of nature and history, for the seeker of adventure and experience. Who would trade the smog of the city for the sparkling mountain air, or the rush of commuter's traffic for the serenity of an upland scene, or the sound of idle chatter for the whisper of a mountain stream? If you would, then take to the wilderness trail!

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"We need to go to school, not in order to learn how to earn a living, but in order to learn how to use the life for which we are going to earn a living—to learn how to occupy ourselves humanly, to live our leisure hours well and not play them all away. We need to learn how to do well what we are called upon to do as moral and political agents, and to do well what we must do for the cultivation of our own minds."

—MORTIMER J. ADLER
*Journal of Higher Education*

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"We know the minimum diet which will keep a child alive. We know the maximum quantity of food he can absorb. But no one knows, no one can even guess how much knowledge a child will want and, if it is presented to him in the right way, will digest. Therefore it is simply useless to teach a child even the elements of a subject, without being prepared to answer his questions about the upper ranges and the inner depths of the subject."

—GILBERT HIGHET
*The Art of Teaching*

# Some Phenomena of Color Perception

• **By Herbert J. Bauer, M.A.,** *(University of Detroit)*
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*So far as color vision is concerned, seeing is not always believing.*

*Bizarre and imaginative color names such as "twin blonde" or "cocoblush" please the fashion designers, but they mean nothing to the scientist. The scientist has a method of classification that serves his purpose better.*

*This paper tells of the basic color classes and how a particular color can be obtained either by mixing pigments or by the retinal mixture of light rays. Various color laws are explained and color blindness is discussed.*

If one were to ask a random group of people to name as many colors as they could, the lists would be impressive. Some of the color names would be common to many of the lists, other names might be quite individual and appear on only a few. We know that the lists would be quite extensive since estimates of the number of discriminable colors is somewhere between one- and three-hundred thousand.

If we attempted to sort the color names given we would find that they could be divided into two general groups: those which were first named by reference to familiar objects, such as "violet" for the flower, "orange" and "olive" for the fruits, and so forth; and those names which are distinctive, but not so particularly attached. It is in this latter group that we would find red, blue, yellow, and green. Intermediate between these two basic lists we would find variations in which an object name has become an adjective before a basic color name, e.g., brick red, and sky blue.

Color names tend to vary with time and locale. In the 16th century, French women's designations for the colors of their garments included such names as Widow's Joy, and Envenomed Monkey. The women of 18th century Paris wore Rash Tears, Paris Mud, and Stifled Sigh. England, too, had a few names of its own: Red-Hot Bullets was the distinctive color of one season. Nineteen hundred thirty was no exception: Folly, Lucky Stone, and Elephant's Breath were fashionable. In 1946, the garment industry was using colors called Twin Blonde, Cocoblush, and the very modern Radar Blue. If the reader is surprised by these names, he need only view the names of current nail polishes (Rosy Future, Plumb Beautiful, Fatal Apple) to see that the tendency to use bizarre color names has not "faded." It is interesting to note that the majority of the color names mentioned earlier do not give any clue as to what the basic color so named actually is.

Any scientific use of such color designations is obviously absurd. In order to standardize the classification of colors for scientific purposes the National Bureau of Standards and the Inter-Color Council after investigating long lists, reduced the various color names to a mere twelve, to be used either singly or in combination.

Becoming somewhat more scientific than the fashion designers of Paris, we can examine our visual experiences and find that they can be divided into two basic classes: 1. those involving modifications from black, through the grays, to white; and 2. those involving what we clearly perceive to be colors . . . the reds, greens, and blues, and all the colors of the spectrum. The former are called Achromatic, and the latter Chromatic visual experiences. It is the chromatic experiences we shall discuss here.

The basis for the particular colors we see lies in the characteristics of the electro-magnetic waves which serve as the adequate stimuli for vision. These "waves" range in length from about 390 millimicrons to 760 millimicrons. The particular color seen will depend upon a specific wave length or combination of wave lengths striking the retina. This individuality of the experience is referred to by psychologists as the "hue."

If one were to examine a set of colored cards, let us say red cards, it would be possible to arrange these

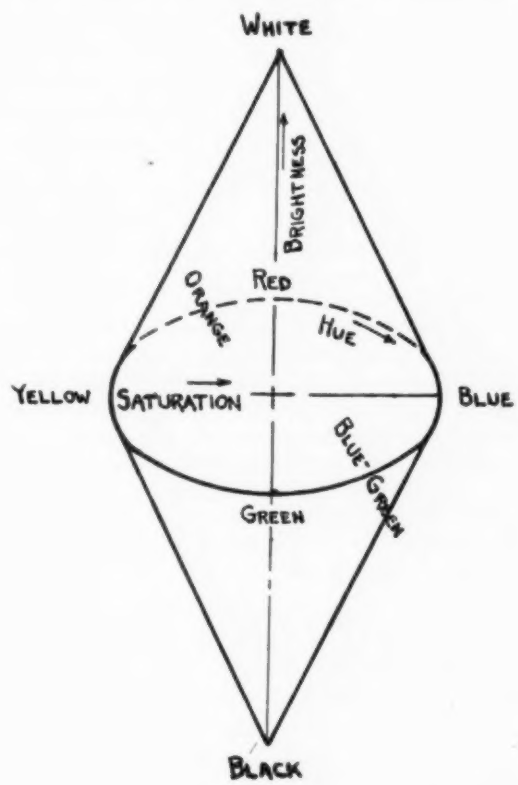


FIG. 1.

cards in terms of their "redness." Basically, they would all be considered red. Compare for example a deep red to a pink. This variation within one major color category is called the "saturation," and is due to the complexity of the light rays reflected by the cards. If the rays are within a narrow range of wave lengths, as a good red might be, the psychologist would say that this color is highly saturated. As the range of the reflected wave lengths increases, and the color becomes less and less dominant, it is said that the saturation has been reduced. This phenomenon can be illustrated by thinking of a bluish red. Such a colored paper reflects primarily those wave lengths which give rise to the experience we call red, but has, in the component reflected, also a noticeable amount of blue wave lengths.

Another inspection of a set of colors reveals the fact that some of the colors, even within one color area, are more brilliant or outstanding. We generally say that one color is brighter than another. This is caused by a difference in the "amplitude" or "intensity" of the wave or waves stimulating the retina. We see then that color experiences can vary along three dimensions: hue, saturation, and brightness. It has been experimentally shown that it is possible to vary any one of these attributes singly or in combination for any color at one time.

The three basic characteristics of the chromatic experience can be represented in a geometrical construct (Fig. 1) in which two cones appear with their bases upon each other and the apexes extending in opposite directions. This figure is generally referred to as the "color cone." The greatest circumference of this double cone at the junction of the two bases represents the variation in hues. The psychological primary colors are red, green, blue, and yellow. The remaining colors of the spectrum lie intermediately between these four colors and are variations of them. The brightness of any color is represented in this geometrical figure by a line extending from apex to apex, vertically through the center of the cones. The greatest brilliance is represented at the apex of the upper cone, and the least brilliance at the apex of the inverted (bottom) cone. Variations in saturation are presented as the radii extending from the center of the color circle where the horizontal plane of the bases and the vertical line of brightness intersect. The point of greatest saturation is at the circumference, reducing gradually as the line proceeds toward the center of the figure. The center of the cone at the horizontal plane of the bases is the point of least saturation, a gray. It is on the surface of this geometric construct that we are able to represent any given color experience.

When a given color is desired it may be obtained in one of two ways: by mixing pigments or by mixing light waves. An example of the former would be to mix, in certain proportions, yellow and blue pigments to form a green.

On the other hand, we may obtain given hues by the addition of light rays in the group striking the eye.

These two processes are fundamentally different. Pigmental mixture for hue is a process of ray *subtraction*. The mixture of light rays (as with filtered lights) is a process of *addition*. In pigmental mixture certain wave lengths are absorbed, and others are reflected. The rays reflected determine the hue experienced. The psychologist, however, is more interested in the process of mixing light rays (addition), particularly as this occurs on the retina—retinal color mixture. In using this method we begin with a given pure light and mix with it certain other light rays; this will result in a color experience different from the original components. The particular experiences which result from retinal mixture of light rays can be described by a set of laws: the Laws of Retinal Color Mixture.

The establishment of complementary hues is fundamental to the laws of retinal color mixture. These hues are diametrically opposed on the circumference of the color cone (Fig. 1). The first law of retinal color mixture states that when complementary hues are retinally mixed in proper proportion the resulting mixture will yield a gray. If we mix yellow and blue in this way we do not obtain green (as with pigments) but instead a gray, for these two colors are psychological complementaries. The same law holds true for any two colors diametrically opposed on the color cone.

The second law indicates that whenever colors which are *not* in diametric opposition are retinally mixed, the resulting experience will be one of intermediate hue and saturation. Therefore, a retinal mixture of yellow and red would not yield gray, but an orange of less saturation than the original red or yellow.

The third law of retinal color mixture states that when a pair of colors which themselves yield gray are retinally mixed in proper proportion with a second pair which also yield gray, the resulting experience will be gray. According to this law all four psychological primaries, for example, could be retinally mixed in such a way that the result would be a gray.

Another interesting group of phenomena of color perception is known as "after images." If one fixates the center of a bright colored patch for a period of thirty or forty seconds and then moves his point of fixation to a neutral background (such as a gray card), it is possible to observe in the visual field an image the shape of the original patch, but of the complementary hue. This phenomenon is known as a negative after image. It will also be observed that if this after image is projected at distances greater or less than the original distance from the eye to color patch, the size of the after image will vary in proportion to that distance. The shape of the after image may assume the shape of the surface upon which it is projected in much the same way as does the image from a motion picture projector when it is directed toward a non-flat surface.

If a visual stimulus is extremely brilliant, and the exposure has not been too long in duration, one may experience an image of the same color as the stimulus. This is usually followed quickly by a negative after

image as described above. The brief image of the same color as the stimulus is referred to as a "positive after image." This can be demonstrated by looking, for a moment, at a relatively brilliant light bulb, and then looking away at a dimly lit wall surface. At first the image of the bright bulb will appear as a positive after image. This will be followed by a dark spot of roughly the shape of the bulb, the negative after image. If the light bulb is extremely bright, it is possible to experience for a moment (previous to the positive after image) a series of colors, usually in a circular shape. This occurrence is called "flight of colors" and can occur, even though the stimulus light was white.

Another interesting phenomenon of color perception is "simultaneous contrast." When we view a patch of color that has been placed upon or very near to a larger area of another color we no longer perceive accurately the hue of the patch. A patch of color so viewed will appear to assume a certain amount of the complementary of the background or proximate color. A red patch on a blue background will tend to be perceived with a tinge of yellow, the complementary of the blue. The best way to perceive the true hue of any patch is to place it upon a gray background, for then there will be no interference from induced hues, for the complementary of the gray is still gray.

In turn, a small gray patch placed upon a larger colored patch will have induced upon it, in the perception, the complementary of that color. Consequently, a gray strip placed upon a red background will appear to have a slight green tint.

The experimental investigation of these phenomena has resulted in the formulation of the Law of Color Contrast. In general this law states that every color in a given visual field will affect and be affected by every other color in that field. The effects of the induced color are shown to be most pronounced when the two colors involved are of the same brightness. It will be seen too, that the induction is maximal at the edges where the two colors meet. Reducing the sharpness of the contour between the two fields will also serve to enhance the contrast. The law of contrast can readily be demonstrated by placing a small colored patch upon a larger field of another color which is of approximately the same brightness. The contours may be reduced by placing a thin sheet of tissue paper over the colors. The induction of the complementary will then be noticeable. This procedure may be repeated by placing a gray patch on a colored background, in which case the induction of the complementary becomes isolated, and more pronounced.

It is interesting to note the practical implications of the phenomena of contrast. They become important in processes involving color matching, choosing colors for signs and posters, and in the combination of the colors of wearing apparel.

Occasionally we come in contact with a person who does not respond to color stimuli in the same manner as the average individual. Such a person may well be color blind. Color blindness is a term applied to the inability of the visual receptors for color to respond differentially to varying wave lengths. For the color blind person, the various wave lengths do not give rise to experiences of different hues. Often the color blind person learns, in his early years, to distinguish "colors" in terms of brightness differences rather than really in terms of hue. Thus he attaches the labels "red," "green" and others on an entirely different basis. However, when the brightnesses of colors are held constant (as in a test for color blindness) the color blind individual is no longer able to discriminate, for his experience is one of equal brightness—some degree of gray. In the situation where the color brightnesses are not held constant the color blind person experiences *different* degrees of gray.

Color blindness is of three major types. The most prominent of these is Red-Green blindness in which the person is able to discriminate all the colors but these two. The second type is much less frequently found. This is Yellow-Blue blindness in which yellow and blue are not perceived as hues. Both of these types are relatively rare. Total color blindness, a condition in which only achromatic visual perceptions are experienced, is very rare.

We have seen that innumerable color names are used in the world of fashion but the scientific designations for color experiences are relatively restricted. We have found also that the process of mixing colors to obtain a particular hue can be accomplished either by subtraction (mixing pigments) or addition (retinal mixture) of light rays. These mixtures follow certain principles as described earlier.

Color experience depends in large measure upon the conditions surrounding the stimulus. Therefore, while certain factors are present in the objective environment a particular experience will not necessarily agree with the objective, external, stimulus field. The old saw, "Seeing is believing," may well merit some revision—at least in so far as color vision is concerned. ●

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"I do not contemplate the production of educated men and women at the age of sixteen. I recommend only these two things: First, our children should be disciplined in the liberal arts, which means the ability to read and write and speak and think as well as they can. Second, our children should experience some intellectual stimulation and be enticed by learning itself. I would hope that somehow the feast of knowledge and the excitement of ideas would be made attractive to them, so that when they left school, they would want to go on learning. In school they must be given, not learning, for that cannot be done, but the skills of learning and the wish to learn, so that in adult life they will want to go on learning and will have the skills to use in the process."

—MORTIMER J. ADLER
*Journal of Higher Education*

# The Spectrograph in Modern Industry

• By Reverend James J. Devlin, S.J., M.S., *(Boston College)*
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*Whenever modern industry requires a rapid, reliable, and economical process for the analysis of any material for low concentrations of metals, emission spectroscopy fills the need. An example: one specially adjusted direct reading spectrograph is capable of analyzing a sample of steel quantitatively for eight elements within a minute's time. Once the procedure has been worked out for any problem by a trained spectroscopist, technicians can carry out routine operations.*

*Here is a fact-filled article dealing with spectroscopy in general, and with types of spectrographs, their construction, operation and uses.*

*You will want to read it more than once.*

Like so many other branches of physics the beginnings of spectroscopy date back to Isaac Newton, who in 1666 caused a beam of sunlight to pass through a circular opening and a prism and then allowed it to fall on a screen forming the first spectrum. In 1801, Thomas Young discovered the principle of diffraction and used a diffraction grating to produce the first diffraction pattern. Around 1817, Fraunhofer designed the spectrograph along the general lines of the modern instrument. He used both prism and grating as the dispersing element and by this means discovered the absorption lines in the sun's spectrum.

Thirty years later, Kirchoff and Bunsen improved the spectroscope and explained the fundamental law of emission and absorption. Their work is generally considered the foundation of spectrochemical analysis. In 1881, Professor Rowland of Johns Hopkins University, in answer to a challenge, produced the first concave grating. The size and quality of his gratings constituted a great advance in the design of high resolution spectrographs. He likewise discovered the Rowland Circle mounting for a concave grating which is the fundamental design of a large number of modern spectrographs.

In common with all instruments the spectrograph is a device for making measurements that reveal the laws of nature. In our present case the spectrograph measures the wavelength and intensity of the radiation from an incandescent source. The sun is the handiest and most obvious source of radiation, and the early work in spectroscopy was concerned with this source. Angstrom was the first worker to make very accurate wavelength determinations, and in recognition of his work, the unit he adopted for wavelength bears his name. The Angstrom is equal to $10^{-8}$ cm. Electromagnetic radiation between the limits of 4000Å and 7000Å approximately, affects the retina of the human eye in such a way as to produce the sensation we call vision. This section of the spectrum is referred to as visible light. From 4000Å to approximately 1000Å is the ultraviolet region. The wavelengths from 7000Å to about 1 mm. or 10,000,000Å is called the infrared region.

This discussion will limit itself to radiation between 2000 and 10,000 angstroms. If the radiation is allowed to pass directly from the source to the slit of a spectrograph, the resulting spectrum is called an emission spectrum. If the radiation from a source is passed through a material before it is allowed to fall on the slit of a spectrograph, the resulting spectrum is an absorption spectrum. We shall limit the present discussion to emission spectroscopy.

The work of Kirchoff and Bunsen along with other experimenters led to a spectroscopic method of analysis of many of the elements. Rowland's contribution provided a tremendous stimulus to the classification and correlation of the spectra of the various elements. Thus there was a mass of data along with a number of empirical equations available when, in 1913, Niels Bohr proposed his theory of the structure of the hydrogen atom. From this time until the middle thirties spectroscopy and atomic structure were almost synonymous. The spectrograph was the instrument used to make the measurements that revealed the structure of the chemical elements.

When the emphasis in research turned to the nucleus, the prominence of spectroscopy was over. However, the spectrograph emerged as a powerful tool for scientific work. One of the chief applications of the spectrograph is to the field of chemical analysis called spectrochemical analysis.

The spectrograph is either a prism instrument or a grating instrument. There are many types of prism instruments but the most common design of modern prism in spectrographs is the Littrow type which in its essentials is shown in the diagram. (Figure 1.)

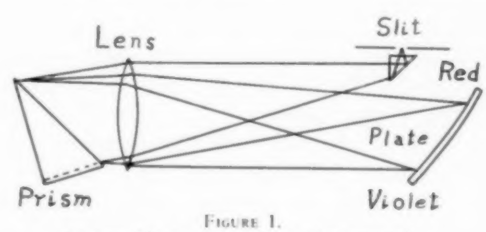


FIGURE 1.
Littrow Mount for a Prism Spectrograph.

If the slit is illuminated by a light source in some suitable manner, the light rays will be reflected by the small prism behind the slit and pass down the instrument to the lens. The lens then renders the beam of light parallel whence it traverses the large prism. The

back face of the large prism is aluminized so as to reflect the light. Upon emerging from the prism the radiation is dispersed according to its wavelength and passes through the large lens for the second time. The lens focuses the light on a photographic plate and produces a series of images of the slit on the plate. This series is ordered according to wavelength and forms a spectrum. If all possible wavelengths enter the slit, the images will over-lap and produce what is called a continuous spectrum. However, if the radiation which enters the slit contains a fixed number of wavelengths, then a discrete set of images or spectrum lines results. These lines will have fixed values of wavelengths, and in addition, will vary in intensity. Furthermore, in general, the larger the prism the greater will be the length of the spectrum and more images will be resolved.

In the case of the grating spectrograph we have several common types. One common type is the Eagle mounting (Figure 2.) which resembles the Littrow mounting of the prism.

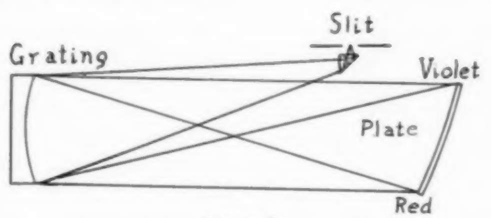


FIGURE 2.
Eagle Mount for a Grating Spectrograph.

Radiation incident on the slit is reflected by the small prism to the concave grating. This device at once disperses the radiation according to its wavelength and focuses it on the photographic plate.

Another type of mounting for the grating is the Wadsworth mount. (Figure 3.)

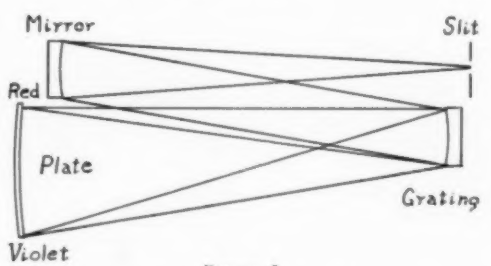


FIGURE 3.
Wardsworth Mount for a Grating Spectrograph.

In this type of mount the radiation passes through the slit to a concave mirror. This renders the light parallel and directs it to the grating which in turn focuses the spectrum on the photographic plate.

The grating element consists of fine lines ruled on a concave mirror. The mirror in a modern instrument will range in diameter from 3 to 6 inches and have from 15,000 to 30,000 lines per inch. The lines must be parallel to one another within a tolerance of one millionth of an inch; and the first and last line should likewise be parallel within the same limits of tolerance. Moreover, they must be spaced with respect to one another within the tolerance of one millionth of an inch.

The extreme tolerances make it very difficult to rule a good grating. There are only a few machines in the world which are capable of producing serviceable gratings. For years Johns Hopkins University was the chief producer of gratings. However, of late, the Applied Research Laboratories, Glendale, California, Bausch & Lomb in Rochester, N. Y., Baird Associates in Cambridge, Massachusetts, Jarrell-Ash Company in Boston, Massachusetts, as well as M. Siegbahn in Sweden have begun to produce gratings of high quality. In recent years several companies have produced replica gratings by impressing a soft plastic with the rulings of a master grating and aluminizing the plastic. These have proved highly satisfactory and much is expected of them in the future.

In the case of the instruments just mentioned, it is possible to view the spectrum by means of an eyepiece. However the infrared and the ultra-violet necessitate the use of some receiver other than the human eye, since radiation in these wavelength regions does not stimulate the retina. A photographic plate provides a good means of producing a permanent record of the spectrum.

Some means must be devised to excite a given element if its spectrum is to be photographed on a spectrograph. The D-C arc, A-C condensed spark, and A-C arc are commonly employed in industrial laboratories. All three types of sources are generally included in a single unit which is called a spectroscopy power source.

Now while it is true that any element may be excited in some manner, and thus give off the radiation needed, the gases and volatile materials cannot be excited by the means enumerated above. For this reason the method of spectrochemical analysis is commonly confined to some 52 elements, chiefly the metals and metaloids.

Samples of the material to be analyzed are mounted in an arc-spark stand in front of the slit. The power is supplied to the stand. A lens focuses the source on the slit or lens of the spectrograph. For arcing, the samples usually take the form of pins which become the electrodes of the arc. However, flat samples may be mounted on an especially designed spark stand called a Petrey Stand. In this case the sample becomes one electrode, and a carbon stick the counter electrode. There are also several techniques for arcing or sparking solutions.

As little as a couple of milligrams of material may be suitably mounted in the arc spark stand for analysis. This gives the method a tremendous advantage when only minute quantities of the material are at hand, or when the material is very valuable as in the case of the rare earths. The presence of very minute quantities of an element is revealed by this method; as small an amount as one part in ten million may be detected in some cases.

In qualitative analysis the complete spectrum of every element present does not appear. For elements

present as major constituents, the major part of the spectrum appears. The minor constituents reveal their presence by a less complete spectrum, and the traces reveal only a few lines called the sensitive lines. Master plates are made up in the modern industrial laboratory in which the positions of these sensitive lines are identified. Then by a comparison technique the analysis of an unknown becomes a rapid and simple process for the experienced operator.

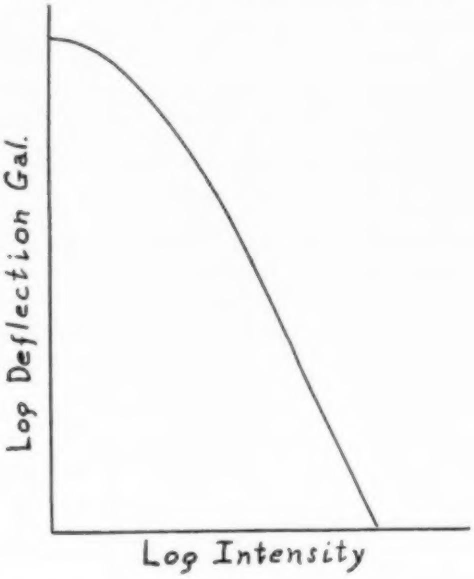


FIGURE 4.
CALIBRATION CURVE of a Photographic Emulsion. This curve is used to convert galvanometer deflection readings to relative intensities.

The spectrograph is more useful in the modern industrial laboratory for rapid quantitative analysis within certain limits. The method is applicable to the analysis of those elements which are readily detected on the spectrograph as mentioned above. The type of spectroscopy described in this article is called emission spectroscopy. In this type of analysis, the arc or spark source breaks down the molecule to atoms and causes these atoms to emit radiation. Thus the method is restricted to detection of elements and not compounds, except by inference. Spectrochemical analysis is more reliable for low concentrations of the order of .001 per cent to 5 or 6 per cent. With special procedures it has been adapted to higher concentrations. Once the procedure has been mastered for a given problem, the method is much more rapid for routine procedures than the ordinary methods of chemical analysis. While a trained spectroscopist is needed to work out the procedures, technicians may be easily taught to carry out the routine operations. As many as 25 or 30 samples may be photographed on one plate; and each sample may be analyzed for 5 or even 10 different elements from the one spectrum.

The quantitative analysis is based on the principle that the intensity of the radiation of certain lines is proportional to the concentration of the element. Thus the density of the line on the spectrum plate can be used to determine the concentration. Owing to the difficulty of reproducing source conditions, developing conditions, and optical alignment from one analysis to the next, spectroscopists prefer the method of internal standard in quantitative analysis. The internal standard may be any element known to be present in a fixed concentration, or it may be an element added. The density of a line from this element will vary with excitation and developing conditions in the same way as the density of the line from what is called the unknown. However, the ratio of these two densities will remain reasonably constant under the varied conditions. This ratio is, therefore, a measure of the concentration.

In most spectrographs the device used to record the radiation is a photographic plate. The density of the developed spectrum line is ultimately a measure of the radiation that has fallen on the emulsion. Thus if there is available an instrument for measuring the density of the line on the photographic plate, there should be little difficulty in converting the density measurements into intensity measurements. The densitometer or microphotometer is such an instrument. In this instrument light from a source, usually a lamp filament, is focused on the spectrum line. The light which passes through this line is then focused by a suitable optical train on a photoelectric cell. The output from this cell activates a galvanometer. Several techniques have been developed by which the galvanometer deflections may be plotted against relative intensities. (Figure 4.)

This is generally called a calibration curve of the emulsion. Such a curve is drawn for different wavelength regions of the photographic emulsion selected for the analysis.

In quantitative analysis, the spectroscopist prepares or acquires standard samples in which the concentrations of the desired elements are known. These samples

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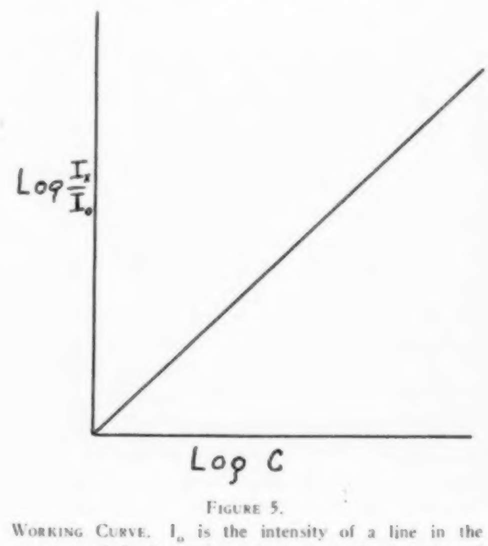


FIGURE 5.
WORKING CURVE. $I_o$ is the intensity of a line in the spectrum of the internal standard. $I_x$ is the intensity of a line in the spectrum of the element under analysis. C is the concentration of the element under analysis.

FIGURE 6. In the foreground is a Large Littrow Type of Prism Spectrograph. In the rear to the right is a small Wardsworth Type Grating Spectrograph.


FIGURE 7. This is the operating end of a six inch, twenty-one foot Wadsworth Mount Grating Spectrograph showing the arc-spark stand, the optical bench and controls of the instrument.

# *Modern Analytical Instruments*

FIGURE 8. This is a photograph of a combination Comparator and Microphotometer. Two sets of plates—one a master plate, the other a spectrum plate under analysis—may be mounted on the riders at the top of the instrument and the images projected on the white screen at the base of the instrument. The galvanometer is in the recess of the base of the instrument but does not appear in the picture.

FIGURE 9. This is a photograph of a Microphotometer. A film from a grating spectrograph is mounted on the carriage of the instrument for densitometering. The photo-cell is mounted inside the black box at the top of the instrument. The galvanometer lamp and scale appear at the right of the picture.

# Help for Elementary School Science

● By Millard Harmon
NEWTON PUBLIC SCHOOLS, NEWTON, MASSACHUSETTS

*One of the valuable services provided by the National Science Teachers Association to its members is the periodic distribution of Science Packets containing educational aids provided by industry. These aids have been approved by skilled evaluators who judge their general character, suitability for use, and possible applications.*

*Mr. Harmon has learned by experience that these materials are valuable teaching supplements. He tells in this paper, which is a condensation of an address to teachers in St. Louis, how he has employed them to good advantage.*

My present teaching position is with the Peirce Elementary School in the Newton Public Schools. I am what might be called a "pseudo-scientist," for my training has included experience in many of the sciences, none of which has been carried to any great depth.

The other day I was walking up stairs to my classroom with a group of third graders. We were just coming from the playground, and as we approached the room I noticed that a youngster by my side was most intent upon the floor. I looked down, also, but didn't notice anything unusual. A moment later there was a tug at my sleeve, and Paul looked up at me and said, "You know, Mr. Harmon, you'd make a *sensational* clown because your feet are so big!"

Well—you can never tell what these youngsters have on their minds, but certainly they have an enthusiasm and a vitality that we can capitalize upon in our teaching. We have in the National Science Teachers Association a real tool for getting these youngsters started in their quest of scientific knowledge. This is, of course, the "Packet Service." To any who are unfamiliar with the Packet Service, may I say briefly that it is an accumulation of educational aids produced by industry which have been evaluated by educators and judged as sound teaching supplements. Several of these packets are sent free to NSTA members during the school year. It is my purpose to tell you how I use this service with my children.

Generally speaking, there are three ways of taking advantage of the material presented in the packets.

*First*, the material may be used to teach the youngsters and then it may be sent home for the parents' use. I can think of two items used in class recently, a pamphlet on conservation of our forests and one on atomic energy, that brought comments from parents for two weeks following the time the children were allowed to take them home. Such printed material on conservation, etc., was not available to the parents when they were in the sixth grade. There is always the possibility of the question being raised, "So what?" In answer to this may I say that it is my opinion that the parents and children of that sixth grade will be less likely to be the cause of any forest fires this summer.

*Second*, there is considerable material in the packet that is directed to the teacher which helps her keep up with advancements in science that she might not know about otherwise.

*Third*, a great deal of the material may be useful in working with the atypical child, both fast and slow. Not long ago I was doing some work with an industrial sponsored aid, Dairy Workit. It was in its original development, and the sponsors were considering the advisability of making it available to the public commercially. I asked all of my groups if they would care to buy Workit. With but one exception all 223 youngsters were anxious for me to exert what influence I could to make them available. The one exception was Carroll, a child in the third grade. He said that he wasn't much interested, because he wouldn't have time for it, really. He was too busy building a three tube amplifier. Carroll's father is an electronics specialist, and this child often uses my resource table where I keep packet material designed for secondary classes.

On the other hand, by the use of scientific comics the reading level and interest of a number of my slow pupils have increased phenomenally. Furthermore, these children have no idea that they are involved in a remedial program, which is an advantage to both pupil and teacher.

In using these educational aids supplied by the packets or by industry itself, there is always the question of how valuable such help is. Obviously there are some aids put out by industry which are so full of advertisement or undocumented fact that they have no place in the classroom. It is the material based on a sound educational philosophy that we are discussing today. Such material is often turned out in sufficient quantity that children all over the nation may take advantage of it. Such widespread distribution will result in a certain amount of standardization of subject matter taught. It is my firm opinion that this type of standardization will in no way hurt the child, nor should it hurt the educational aplomb of the teacher. We are familiar with the classic examples of primary grade misconceptions about cows. "Pasteurized milk comes from cows in a pasture," or "If you wash a cow before milking her, the milk won't be sour." By producing and distributing nationally 100,000 copies of the Dairy Workit, for example, we know that many children in California, or Texas, or Massachusetts will

*(Continued on Page 73)*

# Changes that Occur During the Freezing and Storage of Foods

• By J. D. Winter, M.S. *(University of Minnesota)*
ASSOCIATE PROFESSOR OF HORTICULTURE, DEPARTMENT OF AGRICULTURE, UNIVERSITY OF MINNESOTA, ST. PAUL, MINNESOTA

*The rapidly increasing use of commercial and home quick freezers for foods directs attention to the very real need for sound information concerning the effect of freezing on fruits, vegetables and meats.*

*Here Mr. Winter offers late (February, 1952) information concerning the results of many researches in the field. He reports studies dealing with the rate of freezing, the size and distribution of ice crystals, changes in appearance, vitamin content, texture and palatability.*

*The teacher of science will find this material valuable as background information. Some of it can well be used in the classroom.*

●

Few people are in agreement as to what constitutes "quick freezing." Probably one of the best concepts is that this term means getting the product frozen before deterioration in quality sets in. This implies proper handling of the product all along the line until it is frozen and placed in storage.

### Ice Crystal Formation

During freezing there is a progressive separation of water in the form of ice crystals; the slower the freezing the larger the ice crystals. When foods are frozen slowly, the ice crystals are large and found mostly in the spaces between the cells. Rapid freezing results in many small ice crystals, uniformly distributed within the cell structure, but the rate of freezing required to accomplish this is much more rapid than is possible with the usual locker plant and home freezer facilities.

Furthermore, Ramsbottom[20] has shown that only surface areas of the larger cuts of meat freeze fast enough to produce small ice crystals.

It is well known that the size and distribution of ice crystals depend, in large measure, on the rate at which the temperature of the product falls from just above the freezing point to about 25° F.

The popular belief is that slow freezing results in the rupture of cells, and that rapid freezing prevents this. Examination of fast-frozen meat tissue by Hiner and his co-workers[6] shows the reverse to be true; that is, fast-freezing shatters the cell membrane owing to the expansion of the intracellular ice.

In plant tissues, rupture of the cells by ice crystals formed during slow freezing is not common, since the natural elasticity of the cells and their relation to each other within the tissue prevent this.

Bergh[2] who developed a micro freezing chamber for observing samples under the microscope during the freezing process, reported in 1948 that the amount of ice formed in spaces between the cells depends on the time available for fluids to pass by osmotic action from the intercellular to intracellular spaces. This coincides with previous assumptions. He reports seeing ice crystals sometimes rupture the cell membranes of meat, but observed no rupture of cell walls in the plant tissues studied. He concluded that speculation as to the importance of large or small ice crystals seems unnecessary because after the first formation of ice has taken place, the further formation of ice continues principally by growth from the crystals first formed.

### Effect of Rate of Freezing

Lee and Gortner[13] found few differences in palatability and vitamin content of spinach, corn, and lima beans frozen very slowly, very rapidly, and at intermediate rates. The most rapid rate was in liquid air at −301° to −317° F. The slowest rate was in still air at 0° F. with the product packed in insulated boxes, resulting in a time of 32 to 49 hours to pass through the freezing zone, or 63 to 83 hours to reach 0°F. Similar results with other vegetables have been reported elsewhere.

Few differences in vitamin content, appearance, flavor or texture were reported with strawberries, raspberries, and sliced peaches by Lee and his co-workers[14] where the time through the freezing zone ranged from 15 minutes to 46 hours, or 2 hours to 98 hours to reach 0°F. Recently, a large packer of strawberries slowed down the freezing rate from 4 to 16 hours.

Carlin and his co-workers[3] found no significant difference in palatability between halves of 20 roasters and 20 fowl frozen at 0°F. and those frozen at −30°F. Stewart et al.[21] found no detectable differences in palatability of broilers frozen at −4°F. in still air, at −50°F. in air blast, and at −90°F. in dry ice-alcohol. Similar results were reported by Lee and his co-workers[16] with beef with a freezing time varying from one and one-half to 24 hours to reach 0°F. Pearson and Miller[18] found no differences in cooking losses, tenderness, and palatability of beef frozen in 1 and 20 hours.

The rate and degree of freezing may influence the amount of water reabsorbed. For example, Kethley and his co-workers[12] found a marked increase in leakage after thawing of strawberries when the time through the zone of maximum ice crystal formation (about 31° to 25° F.) exceeded 10 minutes. There was little difference from one-half minute to 10 minutes, and only slight additional increase in leakage with

increase in time beyond 10 minutes. On the other hand, these workers[11] found that the difference in leakage in samples of thawed peaches (after storage of more than one year) taken from the top and bottom of the same container was much greater than between slow frozen and fast-frozen samples taken from identical levels.

These experiments confirm the findings of many workers who have found that the freezing rate and the size of the ice crystals are of minor importance in relation to the quality of most frozen products when freezing is reasonably rapid. However, beef and pork should be placed in the freezing compartment within two hours or less after cutting and wrapping to prevent excessive leakage of juices inside the package. Also, the surface color of some meats and poultry tends to darken when the rate of freezing is very slow or if there is much delay between packaging and the start of freezing.

### Temperature Fluctuations

It was found in our laboratory that the effect of temperature fluctuations on the flavor of frozen ground beef and pork is much less important than the effect of storage time and wrapping material. The work of Pottinger[19] and others[4, 10] indicates that temperature fluctuations, in general, do not have a significant effect on the quality of stored frozen foods unless the packaging material is poor enough to permit excessive desiccation. Evidence indicated that observed differences may be due to higher average temperatures rather than to fluctuations in temperature levels[10, 19].

### Changes In Texture

It is known that the crisp, firm texture of normal fresh plant tissue is chiefly due to cell turgidity which is a function of the water absorbing power of the cell and the availability of water. In non-technical language the living plant cell may be said to retain its turgor by "sucking itself full of water." Other factors involved in firmness of texture are: (a) the type and amount of cell contents, (b) the nature of the cell wall, and (c) the nature of the pectic compounds which hold the cell wall together. The cell composition, particularly the amount of starch present, is an important factor in determining firmness. For example, peas contain much storage starch and are firm upon thawing.

Death of the cell results in an increase in the permeability of the protoplasm. If the stored food in the cell is chiefly soluble, there will be a great loss of solutes and flabbiness of the tissue will be apparent, especially if the cell wall is highly elastic. Much less flabbiness is apparent when the cell wall has little elasticity and great rigidity.

As long ago as 1830, a German worker (Goeppert) showed that the somewhat elastic cell web in plant tissues remained intact during freezing. His explanation of the observed changes in texture was that during freezing water is steadily extracted from the colloids* causing a concentration of salts, precipitation of proteins, and a partial collapse of the cell walls. The dehydration thus brought about kills the protoplasm of the living cell and the dehydrated colloids are deprived of their ability to re-absorb a significant amount of water when the frozen product is thawed. Goeppert's theory has been proved substantially correct by a number of research workers, although there is evidence that this dehydration theory does not hold true under all conditions of freezing.

In cooked foods, a curdled appearance and liquid separation tend to develop in sauces and gravies. Hanson[5] and her co-workers found that the use of waxy rice flour as thickening prevents this.

### Denaturation of Proteins

Protein denaturation has been defined as any physical, chemical, or biological change in the protein that can be measured. During freezing and subsequent storage there may be a coagulation of the proteins and a disrupting of the colloidal structure of the cells. This occurs whether the product is fast or slow frozen. Very little is known about the fundamental processes involved.

Protein denaturation remains one of the most important problems in the freezing and storage of animal tissues. Examples of the results of protein denaturation are: the dry or saw-dusty texture that may develop in fish and poultry; the protein separation or curdling of milk concentrate during storage; the development of flabbiness and toughness of oysters, shrimp and other shell fish; the adherence of the shell of frozen lobster to the flesh after cooking. It is known that the rate of denaturation of proteins is reduced when the temperature is low. For example, protein changes in fish stored for 2 to 3 months are twice as rapid at 14°F. as at −4°F.

### Flavor Changes In Meat

Hiner and his co-workers[7] found that deterioration in palatability of meat during storage is primarily due to oxidation of the fat. This results in off-flavors and rancidity. Chemical changes noted in the muscle tissue appeared to have little relation to palatability. Fat hydrolysis was negligible.

Oxidation of the fat proceeds while meats are held in freezer storage, although the effects are not always noticed since the initial changes do not influence flavor. The rate of oxidation is affected by storage temperature and packaging as well as by the initial condition of the meat. Storage life is increased by lowering the temperature and by protecting the surface from contact with air. Banks[1] found that glazing of fish with ice was effective in retarding rancidity.

### Other Changes in Beef During Freezing and Storage

Hiner and his co-workers[7, 9] have shown that freezing improves tenderness, the lower the temperature of freezing the greater the tenderizing effect. Apparently this is due to the extent of fiber splitting and stretch-

* Colloids refer to substances in a colloidal state, so finely divided that individual particles can not be seen with a microscope.

ing of connective tissues. However, this effect is soon lost during storage due to the tenderizing that takes place[8]. Pearson and Miller found a marked increase in cooking losses, drip, and expressible fluid after storage of 90 days[18].

### Desiccation During Storage

Volz et. al.[23] found that losses of as much as one-fifth of the original weights of green beans, corn, spinach, and peas resulted in no change in texture, flavor, color, surface, appearance, ascorbic acid and carotene content of the cooked product. Changes in appearance were apparent while the product remained frozen.

Winter and Hustrulid[25] found that desiccation (as evidenced by weight loss and freezer burn) is not a reliable criterion for evaluation of the protective value of a packaging material for meat. Results of this study indicated that wrapping materials having low relative permeability to oxygen provided the best protection from flavor deterioration during storage.

### Off-Flavors In Vegetables

The development of "off-flavors" as a result of enzyme action occurs during the storage of unscalded or improperly scalded vegetables. Some persons do not recognize such "off-flavors" as quickly as do others. In this connection it is of interest to note that one person may require 10 times as much salt in a glass of water as another person before the presence of salt is recognized, and 50 times as much as sugar. In fact, one sugar (mannose) tastes sweet to some persons, sour to others. Off-flavors in unscalded frozen peas have been found to be due to fat rancidity[17].

### Color Changes

The color of the frozen product may change during storage especially when the temperature is too high or the storage period is too long. Fish may become yellow or brown (known as "rust"), or fading may occur in fish with colored flesh (as in salmon); beef may darken due to oxidative reactions with the red colored pigments; fruits bleach to a lighter color; the chlorophyll (green coloring matter) of peas may decompose and slowly change to a brown shade when the storage temperature is too high; black spots may develop in shrimp.

Roberston[22] states that fresh meat color and color stability will sometimes change at different rates in different wrapping materials and that color may be readily lost in the wrapped package if the package is not sent directly to the freezer.

### Retention of Vitamins During Storage

Although there is considerable variability among different vegetables in vitamin stability during storage, in general, the vitamin level will not be maintained satisfactorily from one season to another at temperatures above 0°F. Relatively large losses may be expected at 10°F. Carotene and ascorbic acid (vitamin C) are the vitamin factors most likely to be affected. Fruits, in general, show a slower rate of loss than vegetables. These vitamin factors do not comprise major nutrients of animal tissues. ●

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# The Storage Battery

## *A Chemical Storehouse of Electric Energy*

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*This is a discussion of storage batteries—historical development, construction, and operation. The lead-acid battery, Exide-Ironclad, Edison, nickel-cadmium-alkaline, and calcium types are studied.*

*The chemical reactions taking place, maintenance, the use of additives to the electrolyte, operating temperatures, and general care, all receive consideration.*

*Here is good information for the physics class and for the boy who drives a car.*

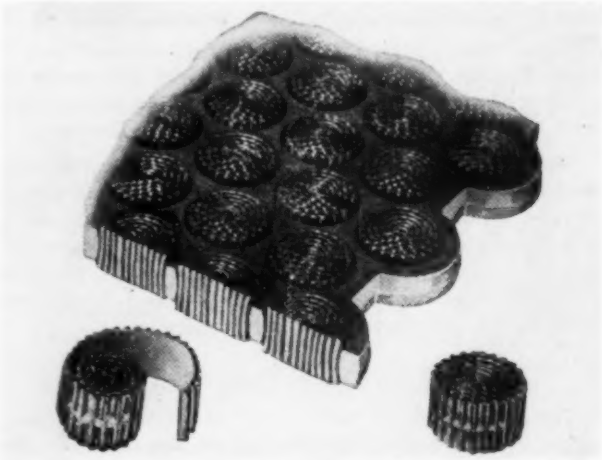

FIGURE 2. Exide-Manchex Plate.

Fundamentally, the Storage Battery is a device for generating electricity through chemical action, but the term is usually applied to a number of such units, commonly called cells, connected together. The storage battery cell, originally called an "accumulator cell," having changed chemical energy into electrical energy over a period of time through a mere change in the chemical composition of the electrodes, and possibly the electrolyte, can be recharged by passing current through it in the reverse direction to that of the discharge current. Thus restored to its original condition, the cell will produce electricity again from the same materials, and this cycling process can be repeated until the end of the useful life is reached.

In 1859 Planté began his study of electrolytic polarization. Using two sheets of lead separated by rubber strips, he rolled them into a spiral and immersed the resulting "element" in a dilute solution of sulphuric acid. It was found possible not only to charge and discharge this simple cell, but also by tedious processing to greatly increase the "capacity" or length of discharge. Later, in 1881, Faure patented a process for pasting a lead compound on the surface of lead plates, thus greatly reducing the time previously required for formation.

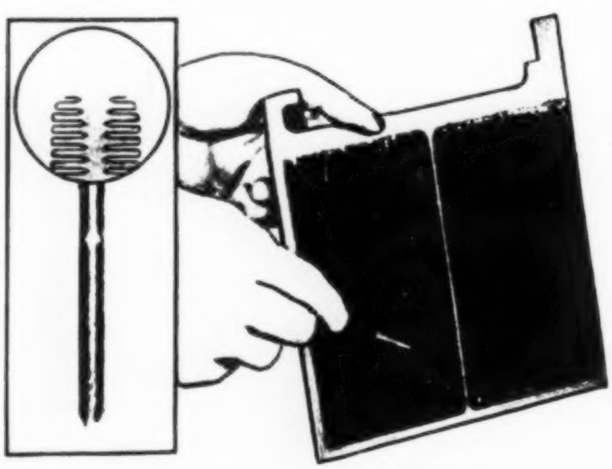

FIGURE 1. Gould Planté Plate.

End of finished plate about ¾ size.

Side view of blank after C. P. process.

The active material of the Planté positive plates is formed directly from the finely grooved pure lead plate itself, as is the case with the Gould Planté positive plate (Fig. 1), or from corrugated extruded strips of pure lead rolled up into buttons and tightly mounted in the holes in an antimony alloy grid, as is the case with the "Exide-Manchex" positive plate (Fig. 2). In the Faure positive plate the active material is pasted on to a supporting alloy grid made up of variously designed vertical and horizontal ribs (Fig. 3). The ordinary automotive battery is the best example of the use of the Faure type positive.

The chemical reaction of the lead-acid battery, according to the generally accepted "double sulphate" theory is: $PbO_2 + Pb + 2H_2SO_4 \rightleftarrows 2PbSO_4 + 2H_2O$. The action which occurs is shown graphically in Fig. 4. When discharging (Fig. 2B), in effect the $H_2SO_4$ of the acid is divided into $H_2$ and $SO_4$. The $H_2$ passes in the direction of the current to the positive plate and combines with some of the oxygen of the $PbO_2$ to form $H_2O$: the $SO_4$ combines with the liberated Pb of the positive plate to form lead sulphate. The $SO_4$ also forms lead sulphate at the negative plate. As the discharge progresses both plates finally contain considerable lead sulphate, $PbSO_4$ (Fig. 2C). The water formed has diluted the acid, lowering the specific grav-

ity of the electrolyte. In common practice the discharge is always stopped before the plates have become entirely changed to lead sulphate.

During charge (Fig. 2D), the lead sulphate, $PbSO_4$, on the positive plate is converted into lead peroxide, $PbO_2$, while the lead sulphate on the negative plate is converted into sponge lead, Pb, and the electrolyte gradually becomes stronger as the $SO_4$ from the plates combines with the hydrogen in the water to form acid, $H_2SO_4$, until no more sulphate remains and all the acid has been returned to the electrolyte. The cell voltage rises slowly during the first part of the charge, then rapidly as full charge is approached and "gassing" increases, and finally levels off at the same time that full charge gravity is reached.

The capacity of a cell is measured in "ampere-hours" (1 A.H. = 1 ampere flowing for 1 hour), or in the amperes of current it will deliver continuously for a definite time, before its voltage falls below a useful value. It is affected by rate (the higher the rate, the lower the capacity), temperature, and various other factors.

The drop in specific gravity on discharge varies with the assembly. Considering a .001 change in gravity as a "point," the drop may vary from 25 or less to 150 or more points for a full discharge. The higher normal gravities are usually used in cells with a limited supply of electrolyte, and vice-versa. The ambient temperature is also a factor, as too low a gravity with the cell discharged should be avoided to prevent possibility of freezing. Local action, a self-discharge phenomenon, is generally present, its importance depending somewhat on operating conditions and being of greater concern where the battery must operate for considerable periods without charging.

The above formula, while fundamental, is only a part of the story. Various substances are added to

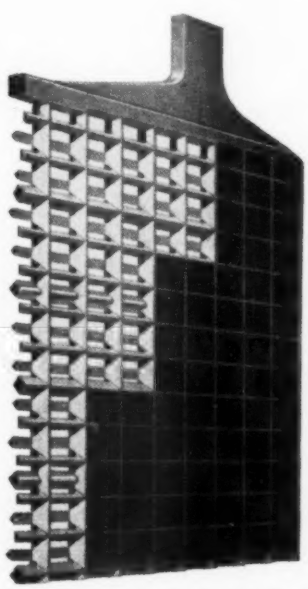

Figure 3. Faure Type (Pasted) Plate.

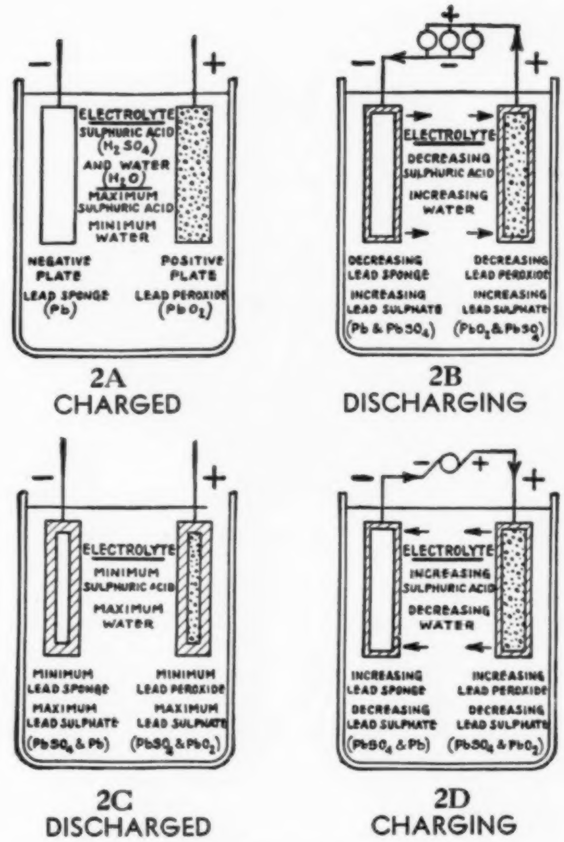


Figure 4. Essential Reactions in Lead-Acid Cell.

the basic paste materials and various processes are used to produce the proper density and hardness, to effect and maintain porosity, to improve the high rate-low temperature, cycle life, float life and other characteristics of the plates.

The normal recharge method is to charge at a suitable "High Rate" until gassing starts and then drop to a safe "Final Rate," or to make the entire charge at a safe rate. The charge is continued until the gravity is restored to the full charge value, with all cells gassing freely. Excessive charging must be avoided, but at times an overcharge is given by continuing the Final Rate until the gravity and voltage, corrected for temperature if necessary, are constant for, say, two to four 15 minute readings. The Constant Potential charging method is seldom practical on account of the high initial charge rates, but under the Modified Constant Potential method the battery is first charged at a comparatively high rate and then at a constant fixed voltage, thus materially reducing the time required for the recharge. The latter is essentially the method now used for all automotive applications.

In the normal assembling of lead-acid storage battery cells, the positive and negative plates are first "burned" to their respective straps to make "groups," and then the groups are interleaved and the separators inserted to form "elements." The elements are

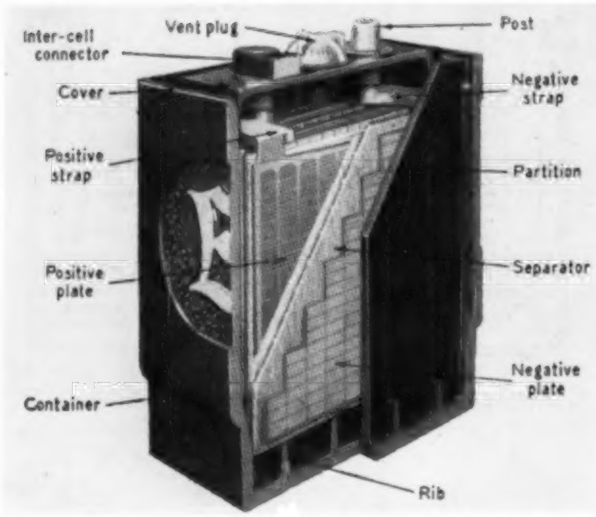


FIGURE 5. One cell of a 3-cell 6-volt automobile battery cut away to show construction.

inserted in individual jars or in the compartments of multi-cell containers and the covers are then applied and sealed in place. The polarities of the cells are usually alternated in order to simplify the placement and "burning" of the intercell connectors. After filling the cells with electrolyte of the proper gravity, the cells are "jar-formed" if unformed plates were used, or given an "initial charge" if the plates have been previously "tank-formed." Instructions are furnished by the various manufacturers regarding the proper processing of batteries which are shipped in any but a "charged and wet" condition. (Fig. 5).

Lead-acid battery elements are mounted in glass, plastic, hard rubber or composition containers, depending on service requirements. Wood, microporous rubber, glass wool, etc., are used for separation, sometimes combined with slotted rubber or plastic retainers. The electrolyte is dilute sulphuric acid, the gravity depending on operating conditions as noted before. The open circuit voltage (cell charged) varies from about 2.06 to 2.12 volts as the gravity varies from 1.200 to 1.280. The average voltage on discharge varies with the rate, but is about 1.96 at the 8 hour rate and decreases as the rate increases. The automobile batteries are all of the Faure type in order to reduce weight to a minimum, and over the years have been greatly improved as regards ability to deliver power under heavy load conditions and at low temperatures.

The positive plate of the "Exide-Ironclad" battery features a series of slotted tubes to hold the active material in close contact with the central conducting cores and to minimize shedding of the material, with a resulting longer life. An important application of the "Ironclad" battery has been in Submarine Service.

The "Edison or Nickel-Iron-Caustic Soda" type of battery was developed by Thomas A. Edison as an improvement on similar types already in use in Europe. The active material for the positives is nickel hydroxide electrically converted to a higher oxide and placed with alternate layers (about 600) of very fine flake nickel in spirally wound perforated steel tubes which are then mounted in a steel frame. The flake nickel is added to improve the conductivity. For the negatives a mixture of fine metallic iron and ferrous oxide, with a slight amount of yellow oxide of mercury added to increase the conductivity, is placed in flat perforated steel tubes and similarly mounted in a steel frame. Separation is provided by hard rubber pins to hold the plates apart, and rubber sheets to insulate the elements from the steel container. The electrolyte is potassium hydroxide, normally of 1.200 gravity, with a small amount of lithium hydroxide added for increased capacity. The fundamental reaction is:

$$Ni_2O_3{,}6H_2O + Fe + 3H_2O \rightleftarrows 2\,NiO{,}9H_2O + FeO$$

The reactions during discharge and recharge are shown graphically in Fig. 6. The results of the reactions consist mainly of a transfer of oxygen back and forth between the positive and negative plates. Since the electrolyte does not apparently enter directly into the chemical reactions, the gravity shows no measurable change, hence gravity readings give no indication as to the state of charge. This battery uses the standard arrangement of plates (outside negatives), but the plates are bolted to the straps. The cells are exclusively factory assembled and all seams are electrically welded.

The open circuit voltage of the Edison Cell is about 1.45 volts and the average voltage on discharge at the 5 hour rate is about 1.20 volts. On account of the ready adsorption of carbon dioxide from the air by the electrolyte, the filling vent includes a valve to prevent entrance of air to the cell. The battery is usually charged at a constant rate equal to the 5 hour discharge rate, but a modified constant potential method is used in some applications.

Among other types of storage batteries are the "Nickel-Cadmium-Alkaline" and the "Calcium" Cells. The former is similar to the Edison Cell except that it uses cadmium and iron oxides in the negative plate. In particular, good operation at low temperatures is claimed. The latter, or Calcium Cell, is similar in appearance and discharge characteristics to the conventional lead-acid cell, but the alloy used for grids

*(Continued on Page 76)*

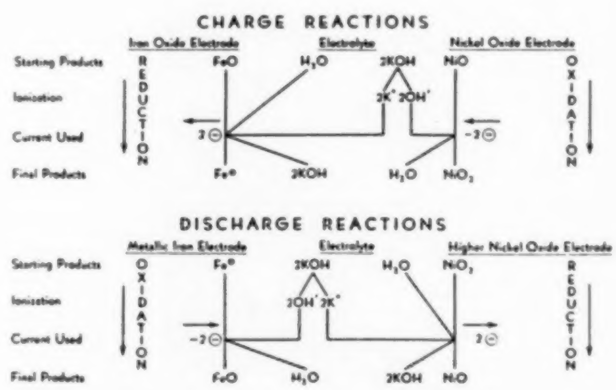


FIGURE 6. Essential Reactions in Edison Cell.

# On Assimilation of Atmospheric Moisture

• By George Antonoff, D.Sc., *(University of Manchester)*
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*This is an account of how a curious natural phenomenon may be explained, and how the major problem of water supply may eventually, in certain regions at least, be solved by the application of a theory developed by the writer in his laboratory.*

*Dr. Antonoff is well known for his pioneering studies of surface tension and the structures of liquids.*

For fifty years I have been working on the problem of liquids. During this period the attention of scientists generally has been focussed on atomic phenomena and the solid state. Consequently the important subject of liquids has not received the attention due it, when it is remembered that the chief constituent of our bodies and of every living thing is water, and all the processes connected with life take place in solutions. I found more response to my work in its early stages from biologists and medical men than from physicists.

In liquids I have found it possible to observe simple relationships hitherto unknown. The chief difficulty was finding a suitable method of investigation. I happened to concentrate my attention on surface tension, which according to the generally accepted view, throws light on the surface properties of matter. Curiously enough I discovered that, contrary to all expectation, this property is a clue to an understanding of what takes place *within* the liquid. This enabled me to formulate a comprehensive theory, which proved to be a most efficient method, better than any other known.

Surface tension in its true meaning is neither a popular subject in this country, nor is it properly understood. As a matter of fact in most textbooks the definition of surface tension is either not given at all, or when given, is wrong. Yet this subject has many potentialities of practical nature which make its further exploration extremely important.

Many years ago I was approached by a friend, a forest engineer, who asked for my cooperation in studying the problem of shortage of water in agriculture and in determining possible ways of alleviating it. (This article is written at a time when the problem is very acute in the United States.) My cooperation was needed because he was confronted with facts which he himself could not understand. A physical chemist was needed to interpret them and my line of research on liquids appeared to be closely related to this subject.

The task was reforestation of regions devoid of all sources of subterranean water. There was no source of water of any kind anywhere in the vicinity, as ascertained by the geological survey of the region in question; yet a slope was found there from which water was constantly debiting in quantities worth considering. It appeared almost miraculous. Nobody could understand where this water was coming from. Superstitious people thought it a miracle, or the work of evil spirits.

After giving some thought to the question, I could see only one source of water, namely, the moist air from the sea which was located not too far from this mysterious slope. It seemed evident that the slope was in some way responsible for the condensation of atmospheric moisture carried by the saturated air blowing from the sea by the prevailing winds. It is significant that at some distance there was another slope which showed no sign of water whatsoever. On comparing the two slopes a marked difference between them was found. One was covered by fragments of a rock which were so uniform that they gave an impression to have been gauged. The other was quite different in appearance. I could devise no reasonable theory of any kind capable of explaining why one type of fragment should be capable of condensing moisture and not the other. Finding no solution of the problem, I was inclined to drop the matter altogether and to divert my attention to an entirely different subject.

My interest in the matter was soon unexpectedly revived, however, due to circumstances which appeared to have no connection whatever with the problem mentioned.

At that time in qualifying for a professorship I had to pass a test in crystallography. My professor of crystallography asked me what was my specialty. When I told him that I was working on the surface tension of certain liquid systems, he charged me with the problem of collecting all possible information about the surface tension of solids. I was taken by surprise, and at first I did not take him seriously. I had thought that surface tension is a property characteristic only of the liquid state. No allusions to solids could be found in the treatises of those days. After a tedious search I found, however, that quite a substantial amount of theoretical work on the surface tension of solids had been done by Willard Gibbs as far back as 1878[1]. A little later came a very interesting work of Pièrre Curie[2]. All this work was much ahead of the time. It remained dormant for nearly half a century, because *methods of measuring the surface tension of solids experimentally did not exist.*

There appeared to be no indication of any kind, not even a hint, that such methods could be or ever would be found. However, at that time I had already discovered the important relation known as Antonoff's Law,

$$\gamma_{12} = \gamma_1 - \gamma_2,$$

connecting the surface tensions of two media in contact with each other. Here $\gamma_1$ is the surface tension of one medium, $\gamma_2$ that of the other, and $\gamma_{12}$ is the tension

of their interface. Antonoff's Law provided a clue to the solution of several important problems in connection with liquids, and ultimately this law enabled me to devise the method of measuring the surface tension of solids.

The above relation is valid in all cases when two media are in contact with one another, *provided they are in thermodynamic equilibrium**, no matter whether they are liquid and liquid, liquid and vapor, or liquid and solid. Two partially miscible liquids present the best object for experimentation, because all three magnitudes can be determined experimentally by known methods.

When a solid is in equilibrium with a fluid the relation acquires the form

$$\gamma_{sl} = \gamma_s - \gamma_l$$

where $\gamma_{sl}$ is the interfacial tension, $\gamma_s$[3] is the surface tension of the solid, and $\gamma_l$ is the surface tension of the fluid. The latter is the only quantity which can be measured by known methods. By using certain solutions or mixtures whose surface tension can be changed at will, one can make their surface tension equal to that of the solid. It can be seen that when the surface tension of the fluid exceeds that of the solid, there is no wetting of the solid by the fluid. On the other hand, when the surface tension of the solid exceeds that of the liquid, the latter begins to adhere to the solid. By locating the transition point one can adjust the surface tension of the fluid so that it becomes equal to that of the solid.

In such cases, $\gamma_{sl}$, the elusive property for measuring which no method exists, becomes equal to zero. We have only to measure the surface tension of the fluid, say, by the capillary method and this will give us the desired answer, i.e. the value for the surface tension of the solid, because $\gamma_s = \gamma_l$.

The correctness of the theory can be tested with certain substances, for example, paraffin. For one variety of paraffin the surface tension was found to be 40 dynes per cm. By liquefying it, its surface tension can be measured at two different temperatures and extrapolated to the melting point. The figure thus obtained very nearly coincides with the one given above.

The figures found so far for a number of solids vary between 30 to 900 dynes per cm. Thus, the magnitude of the force is widely different in different substances. Moreover, the latest evidence indicates that the range of force may also be different.

Substances with low surface tension repel water like a goose which comes out of the water completely dry. These substances are called *hydrophobic*. Substances with high surface tension attract moisture with a widely differing force, and are termed *hydrophilic*.

This theory is capable of throwing light on the behavior of the mysterious slope mentioned at the beginning of this article. As far as one could see, it was covered by fragments of an ore brought from somewhere else. These fragments were of more or less uniform size. These characteristics made us think that the slope was not a natural phenomenon—nature does not practice such things—and our hypothesis was that it must be a man-made construction, erected with the object of assimilating atmospheric moisture. Considering the known history of these regions, one could conjecture that it was one of the evidences of activity of the Genoese, who left traces of various kind in these parts. They appear to have been the only civilized people to whom such work could be attributed.

Laboratory experiments I conducted at the time proved the remarkable fact that by the right approach very much indeed can be done to increase the yield of water condensed on a solid. They also showed that the problem was not a simple one, and many experiments had to be made before all the angles could be fully clarified. I observed that in certain atmospheric conditions, two objects made of different material behaved differently: one was dry and the other wet. This difference I correlated with the difference of surface tension of the solids and I found that substances with high surface tension show themselves hydroscopic, that is to say, that they condense on their surface moisture above the dew point.

In the face of this preliminary work we found no difficulty in raising the necessary funds in order to erect a similar slope, but world events forcibly put an end to this work just at the moment when the final stage was within reach. Many times in my life it has happened that work nearing completion has been interrupted by sudden crises, by revolutions and wars.

This project can be revived and become a practical proposition. It would have particular success in those parts where metereological conditions are favorable, mentioning only one instance, those parts of the country which are adjacent to the Gulf of Mexico. Here is a steam bath evaporating colossal quantities of water, wasted at present, but which could be utilized with great benefit.

Even in the driest deserts there is enough atmospheric moisture to support vegetation. Dig into the sand which is dry on the surface, and at a certain depth it appears moist. Plants are capable of assimilating moisture in various degrees direct from the atmosphere, the cactus for example. This particular phenomenon gave me another idea of developing a biological method for the assimilation of atmospheric moisture. Its importance cannot be minimized because if one could only find a suitable way of reforesting dry regions, one would immediately observe a complete change of climate. Where before the deposition of moisture was unknown, or nearly so, it would become frequent.

This paper outlines two methods for assimilating atmospheric moisture. It would be of considerable advantage to initiate research in both these methods simultaneously. ●

* Albert Einstein drew attention to the importance of this condition. See *Colloid Chemistry*, Ed. Jerome Alexander, Vol. VII, 83 (1950), N. Y.

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# Complex Reproductive Processes in Bacteria

• By Sister Mary Benita, C.H.M., M.S., *(St. Louis University)*
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*Although the belief is commonly held that bacteria multiply exclusively by binary fission, bacteriologists are trying continually to discover evidence of a sexual cycle.*

*This scholarly paper reports work that has been done in this area, and points out that although complex reproductive processes in bacteria are either uncommon or not readily demonstrable by today's methods, such phenomena probably do occur.*

The idea that complex reproductive processes exist in bacteria has persisted throughout the history of bacteriology. Although the consensus is that multiplication is exclusively by binary fission and studies undertaken to show sexual modes of reproduction in bacteria have been suggestive rather than conclusive, bacteriologists today continue the series of those who have attempted to find evidence for a sexual cycle.

The geneticist, particularly, finds interest in the problem; for binary fission makes possible the segregation of hereditary characteristics, but it offers no means for new combinations and rearrangements of them. During the past ten years the fungi, particularly the Ascomycetes, have gained popularity as material for genetic studies. Although they may never compete with maize and drosophila, microbes, with their magnitude of population, the facility with which critical factors in their environment can be altered, and the abundance of physiological variation among them, offer excellent material for genetic studies. Since genetic and external specific factors interact in the synthesis of enzymes, the biochemist should know something about studies showing recombination in bacterial genes. Bacteriologists, especially those interested in growth studies, would find their conclusions affected if complex reproductive processes were found to occur in bacteria. Finally, all biologists welcome information on reproduction since it is one of the fundamental processes in living things.

The earlier studies on syngamic processes in bacteria were mainly morphological, but in keeping with the current trend in bacteriology, contemporary experiments are physiological.

In 1921 Löhnis[1] published a detailed review of microscopic observations of scientists from 1838 to 1918 suggestive of sexual cycles in bacteria and postulated that synplastic stages—mixing of many cells—and congregation—a direct union of two or more bacteria—took place during bacterial life cycles. In spite of Löhnis' evident favor of the idea of complex reproduction in bacteria and his publishing 297 plates from his and other laboratories possibly showing these processes, he was not able to demonstrate his thesis in a conclusive manner.

Mellon[2] considered that the bacterial stages known as involution forms were zygospores, and that the morphology of isogametes and zygospores in the colon-typhoid and diphtheria groups was similar to that seen in yeasts.

*Agrobacterium tumefaciens*, a plant pathogen with a history of changing names, may produce peculiar star-shaped aggregates of cells which have the appearance of a sexual stage. Three hours after cultures have been transferred from nutrient glucose broth into carrot broth, aggregates begin to form. Individual bacterial cells come to rest at or close to the surface of the medium, a second moves into the vicinity of the quiescent first organism, and so on, until there are two to several hundred organisms aggregated. Braun and Elrod[3] studied films of these aggregates with both light and electron microscopes. They noted that the flagella are attached to the end of the cell farthest from the center of the aggregate, disposing of the idea that the attachment is due to flagellar entanglement. In some cases there was a segregation of Feulgen positive material at the center of the aggregation. This sugested that nuclear material had been transferred from one cell to another, but there was no evidence of fusion of bacteria or protoplasmic strands.

It has been sugested by Dienes[4] that the large round bodies observed under certain conditions in *Streptobacillus moniliformis* are the result of some sexual reproductive process. In *Proteus* this process appears regularly when spreading cultures of appropriate strains come in contact. Although no union of cells has been demonstrated, the large bodies are produced only if spreading filaments meet other spreading filaments.

Although there have been many observations on the morphology of the bacterial cell, and Almquist[5] postulated over 25 years ago that variation in nuclear staining corresponded to diploid and haploid stages in bacteria, its intimate structure is still not sufficiently well known to equate anything with the nucleus of higher organisms. Thus cytological studies alone are inadequate to determine an answer to the question of whether reproduction in bacteria takes place only by binary fission.

The phenomenon of paragglutination in the colon-typhoid-dysentery group of bacteria has been interpreted by Almquist[5] as an instance of bacterial hybridization. Paragglutination refers to the development of new types which react with antisera for each of the two distinct strains when these are grown together in a mixed culture. Hansen[6], on the other hand, failed to obtain paragglutination. After she had cultivated *Escherichia coli* and *Salmonella typhosa* in mixed cultures for 17 generations and from the last generation

in the series tested lactose-fermenting colonies with anti-typhi serum, she found the titer was the same as that obtained when the original strain was tested against the anti-serum. Each of these two workers finds a number of bacteriologists who agree as well as those who disagree, so the antigenic approach to the problem remains open.

One of the most recent and extensive studies to establish the idea of a sexual mode of reproduction in bacteria is the outgrowth of a Yale doctoral dissertation by Lederberg working with Tatum[7]. In 1937, Sherman and Wing[8] introduced the idea that if conjugation or other sexual processes occur in bacteria the fact might be evidenced by physiological tests. Various strains of *Escherichia coli* and *Aerobacter aerogenes* with different fermentative qualities were grown in mixed cultures and the progeny tested for recombination of genetic factors. The authors were unable to differentiate the new types found in their mixed cultures from types which arose spontaneously in single cultures. They blamed part of their failure on the use of recent isolates.

The Lederberg experiments[9,10,11,12] were performed with mutants of a single strain of *Escherichia coli*, K-12, a typical coliform, gram negative, motile, lactose-fermenting, indol-producing strain, susceptible to a series of phages, and used for a number of years as a student laboratory strain. Mutant strains characterized by specific growth requirements and phage resistance were obtained after treatment with x-rays, ultraviolet light, and nitrogen-mustard, and the nutritional characteristics ascertained by inoculating media consisting of a basal medium plus various supplements, with lack of visible growth the criterion for determination of nutritional requirements. Strains which possess the growth requirements under consideration are called prototrophs, since this is the condition of the parental wild type. The all-over frequency of spontaneous mutations in pure cultures of the mutants in untreated cultures was less than $10^{-7}$.

Since coincidental spontaneous reversion to two or more factors did not occur at a sufficiently high rate to be detected, the presence of prototrophs in mixed cultures of multiple mutants was considered evidence for gene combination. Each mutant was capable of synthesizing the growth factors for which it was not deficient; thus the different mutants were considered to have "+" alleles for all but the two or three genes which characterize each strain. The segregation of prototrophic alleles of every gene into one cell would result in a prototroph. It would develop into a visible colony on the minimal synthetic medium; whereas other mutant cells would be unable to proliferate, owing to the absence in the minimal medium of their nutritional requirements. For example, when washed samples of a young, biotin-requiring, methionine-requiring, proline-synthesizing, and threonine-synthesizing culture, and a young, biotin-synthesizing, methionine-synthesizing, proline-requiring, and threonine-requiring culture were mixed and plated onto a minimal medium, about 100 colonies developed for each billion of cells inoculated. No colonies appeared after inoculation from the individual double mutants. One interpretation of the occurrence of the prototrophs is that the genes for the synthesis of the four substances segregated into the same cell. Perhaps the best evidence for the homogeneity and uniqueness of the prototrophs isolated from the mixed cultures was their relative stability, tested in the original and other laboratories.

A phenomenon which might influence the conclusions of those studying bacterial descendants of a mixed culture is that of a transforming principle, such as desoxyribosenucleic acid, which Avery *et al*[13] found would convert non-specific, rough pneumococcal types into the specific, smooth type characteristic of the source of the principle. In the Lederberg experiments attempts to modify a nutritional mutant with a culture filtrate from another mutant or with desoxyribosenucleic acid were not successful.

To account for these results Lederberg and Tatum postulated a sexual phase in *E. coli*, strain K-12—a cell fusion which would allow the segregation of genes in new combinations into a single cell. The former has attributed the apparent low recombination rate to several possible causes, first, that there might be an analogy between the numbers of somatic and generative cells in *E. coli* and organisms like the oak or man, or secondly, that experimental conditions were not optimal for zygote formation.

Earlier studies led Lederberg to postulate that the life cycle in *E. coli*, K-12, would resemble the Ascomycetes in which haploid nuclei fuse to form a transient diploid zygote which undergoes meiosis without any interfering mitoses, but later work led him to propose the hypothesis that diploid heterozygotes occur[14].

Workers in other laboratories[15,16,17] have used *E. coli*, strain K-12, to confirm Tatum and Lederberg's theory of regular recombination in this strain. Although Cavelli and Heslot[15] obtained one positive result in an outcross test with K-12 and other *E. coli* strains, the former strain stands otherwise alone as a physiological demonstration of recombination of genes in bacteria, and by inference, of syngamy in bacteria.

Although the evidence accumulated thus far indicates that complex reproductive processes in bacteria are either not of common occurrence or are not easily demonstrated by methods now employed, these phenomena do seem to take place. ●

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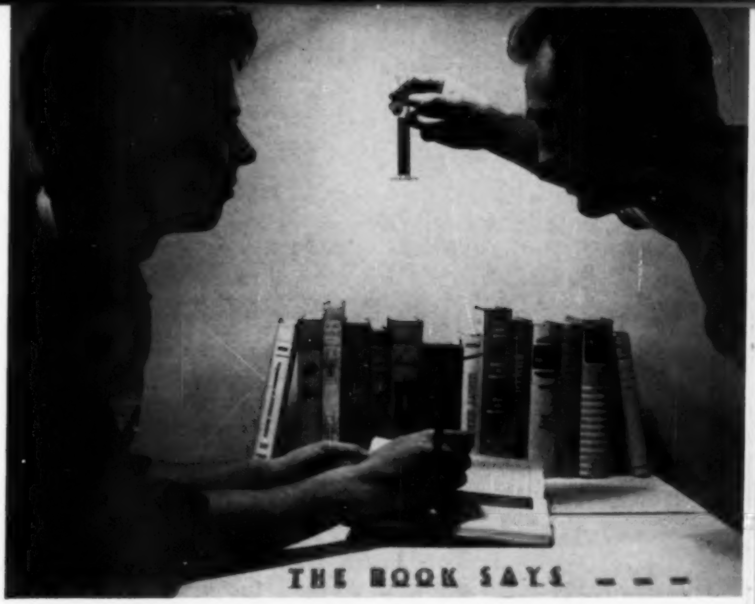
*(Continued on Page 76)*

# NEW BOOKS




## Science for Modern Living Series

• *By* VICTOR C. SMITH, KATHERINE CLARK, BARBARA HENDERSON, and W. E. JONES. Philadelphia: J. B. Lippincott Co. 1951.

The nine books of this series were each assigned for review to a teacher at the grade level indicated. The teachers' collective reports were favorable, indicating that these books contain certain important features which of themselves recommend the use of this series in the schools.

Care has been taken to make sure that the subjects treated in each book come within the child's environmental experience. The experiments described are simple and clear. Vocabulary is carefully adjusted to grade level. Sentences are short and to the point, a feature which helps sustain interest. Sentence sequence is logical, making for easy reading. The narrative style of presentation adds to the attractiveness and acceptaiblity of the series. Type is large and clear, illustrations numerous and colorful, and binding durable and attractive.

Each book is divided into units, chapters, and problems, one problem constituting a day's work. The units contain suggestive activity programs, self-tests, mastery tests, word lists, principles for memorization, visual aids, references, demonstrations and experiments. There are well defined glossaries. A Teacher's Manual and unit tests are available.

*Sister M. Gabrielle, O.S.F.*
*St. Francis Academy*
*Pittsburgh, Pennsylvania*

## Science for a Better World

• *By* MORRIS MEISTER, RALPH KIERSTEAD and LOIS M. SHOEMAKER. New York: Charles Scribner's Sons. 1952. Pp. VI + 778. $3.20.

A ninth grade book carefully designed for ninth grade students and well fitted to their needs. Concerning the first edition, this reviewer reported: "This textbook is an outstanding contribution to science instruction in secondary schools. Its general plan has been carefully developed. The book is wholly modern and unusually teachable and does not make the mistake of underestimating the intelligence and awareness of the average ninth grader. It should stimulate the teacher as well as the pupil, for only a well-informed person will be able to answer the questions this text will raise."

The second edition deserves equally favorable comment. There is considerable new material and a generous revision of some of the old. Encouraging student helps, and many interesting and thought stimulating illustrations are provided. Some color plates are not as well done as they should be. There is an occasional loose statement, probably not to be avoided in a book of this kind. But these are very minor criticisms of an estimable text.

*H. C. M.*

## Your Precious Eyesight

• *By* L. LESTER BEACHER, O.D., O.Sc.D. New York: Psychological Library. 1952. Pp. x + 84. $3.00.

In this interesting little book is concentrated much information about the eyes and eyesight. Written by a distinguished optometrist mainly in question and answer form, it gives straightforward answers to questions that often plague laymen, but which too frequently are left unanswered. After outlining the special duties of the ophthalmologist, the optometrist, and the optician, Dr. Beacher discusses common types of eye defects and their correction. He considers ordinary eyeglasses and contact lenses, the use of exercises, eye changes with advancing age, adjustment to bifocals, the effect of television on the eyes, tinted lenses, reading in moving vehicles and many other questions.

Do farmers usually have better eyesight than city people? Can visual speed be increased? What about plastic lenses for regular eyeglasses? Can bad teeth cause visual defects? These and many other topics are discussed in terms the layman can understand.

*H. C. M.*

## Zoology in Postage Stamps

• *By* W. DENNIS WAY and O. D. STANDEN, M.Sc. New York: Philosophical Library. 1952. Pp. VII + 113. $5.00.

A book primarily for the philatelist. Since a distinguished English philatelist and a Fellow of the Zoological Society collaborated in its production, it may be accepted without question as an authoritative guide. The writers have searched diligently to find stamps on which living animals of various kinds form a significant part of the design. Nearly 300 examples are reproduced in fine detail in black and white. Mammals, birds, reptiles, and fishes are represented. Among the invertebrates are anthropods and molluscs. Brief descriptions are given of the basic characteristics of each species shown, but there is no attempt at elaborate zoological detail. Enough information is given, however, to stir the stamp collector's interest and to assist him in classifying his collection. There is

a brief bibliography and both philatelic and zoological indexes.

This is a publication of distinct worth in its field. It is regrettable that the illustrations could not have been made in color.

*H. C. M.*

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## Free Radical Chemistry

*(Continued from Page 38)*

tions, many metals of the sub-groups of the Periodic Table such as tin, lead, antimony, tellurium, etc., are readily removed with formation of the corresponding organic compound. Paneth found that suitable conditions were a rapid stream of hydrogen (10-20 meters/sec.) at low pressures (1-2 mm.) carrying a small amount of the lead alkyl. The gases pass through a furnace heated to about 600° C., the lead alkyl decomposes, depositing hot lead just beyond the exit end of the furnace, and the free radicals pass down the tube where their presence can be shown by their effect on cold mirrors placed at different distances from the end of the furnace. (Fig. 1.)

By measuring the time of removal of standard mirrors placed at different distances from the end of the furnace, Paneth showed that the concentration of the radicals fell rapidly and their half life was found to be only a few hundredths of a second. Obviously free radicals having such a short half life can be studied only by a technique specially adapted to a situation in which particles combine or disproportionate practically completely in a small fraction of a second.

It turned out that almost the only reaction that free radicals undergo at surfaces besides reaction with themselves is reaction with metallic mirrors. The conditions for reaction are: (1) a metallic mirror is necessary; the radicals do not attack the metal in bulk. This suggests that the metal atoms are more easily removed from the disordered atoms comprising the mirror than from the regular crystal lattice; (2) a clean metallic surface. If the surface is covered even with the thinnest film of oxide or sulfide, the metal is not attacked.

Until quite recently almost the only direct way to study free radicals was to combine them with metallic mirrors and examine the organo-metallic compounds formed. However, the work now in progress in the author's laboratory has shown that it is possible to freeze out free radicals on a surface cooled with liquid nitrogen and study the product at leisure. A number of new radicals have been obtained by this method and one of them, which has been studied in detail, will be described.

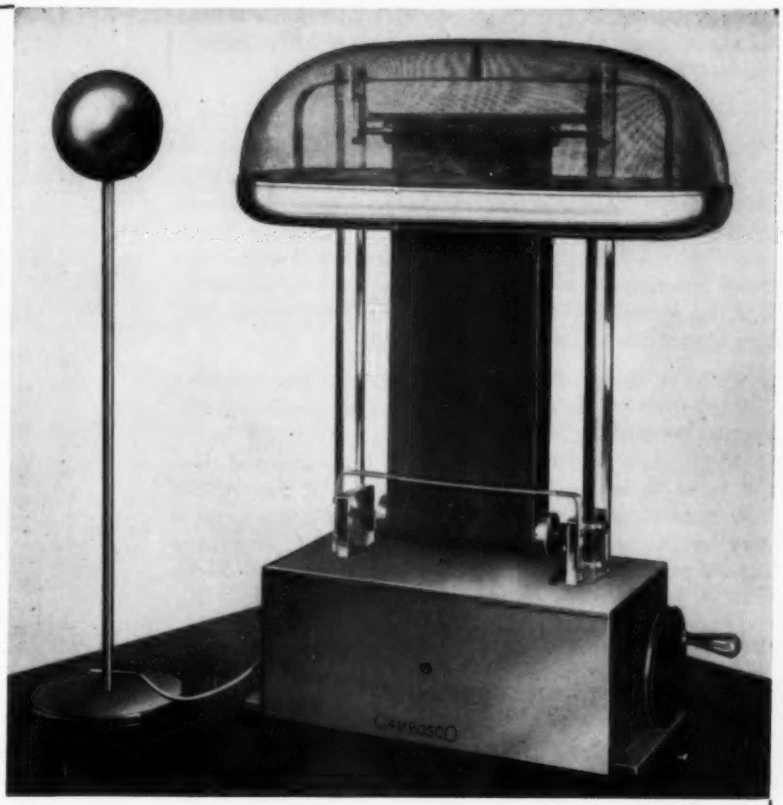
In experiments by F. O. Rice and Melvin Freamo, it was found that when hydrazoic acid was passed

# FIRSTURN* ELECTROSTATIC GENERATOR

**Of Van de Graaff Design★**

## *Delivers Discharge of 200,000 Volts▲*

***Self-starting and self-exciting. Needs no "priming." •Requires no auxiliary power supply. •Involves not the slighest hazard to operator or observer.***




### SPECIFICATIONS

Like its larger prototypes, the Firsturn Electrostatic Generator consists, essentially, of an endless, charge-conveying belt, which, as the crank is turned, moves into and out of a hollow metal terminal. Thus is the Van de Graaff principle reduced to its simplest, most comprehensible terms.

The belt travels upward from a solid metal roller to an adjustable, insulating roller which is supported on massive pillars of *anti-static* plexiglass. Those pillars likewise support the discharge terminal which, for visibility, is fashioned from woven bronze gauze. At the top of the terminal, provision is made for leading the charge to a Leyden jar, or to any of the accessories commonly employed with static machines.

Although the Firsturn Generator is primarily designed for hand operation, the drive wheel is grooved, to serve as a pulley when a motor drive is desired.

A mounted discharge ball, of heavy brass, is furnished with each Firsturn Generator. Jacks are provided for connecting that ball to the generator base, and for grounding the generator. Operating instructions are included.

Principal dimensions are as follows: Height, overall, 21-3/4 in. Width of terminal, 16 in. Width of belt, 5 in. Size of base, 6 x 13-1/2 in. Diameter of discharge ball, 3-1/2 in.

### NOTES

•So named because a spark is produced at the first turn of the crank.

★Licensed under United States Patent No. 1,991,236, as issued to Robert J. Van de Graaff.

▲A conservative rating, based on many trials under average operating conditions. Under ideal conditions, a potential difference of 300,000 volts has been achieved.

*At the first turn of the crank,* this modern Electrostatic Generator emits a crashing spark, whether the day is dry or humid! For that reason alone, it will be welcomed by every physics teacher who has ever apologized for the temperamental performance of an old fashioned "static machine."

NO FRAGILE PARTS. The Firsturn Generator is constructed entirely of aluminum, brass, plexiglass, rubber, steel and wood. There are no Leyden jars; in fact, no condensers of any kind. There are no plates to warp or break; no shunts, brushes or collectors to adjust; no segments or button disks to re-stick!

NO "TRANSFER BODIES." In conventional influence machines, whether of Holtz or of Wimshurst type, charges are collected and conveyed (from rotating plates to electrodes) by a system of "transfer bodies." Such bodies include: brushes, rods, button-disks, and foil or metal segments, each of which, inevitably, permits leakage of the very charge it is designed to carry, and thereby sharply limits the maximum voltage. In the Firsturn Generator (but in no other self-exciting electrostatic machine) electrical charges are established *directly* upon the discharge terminal.

AT THE LECTURE TABLE, the Firsturn Generator enables you not only to perform the classical experiments in static electricity, but also to demonstrate the *modern method* of building up tremendously high voltages for atomic fission, for nuclear research, and for radiation therapy.

**• • • *Available for Immediate Delivery***

**No. 61-305 FIRSTURN ELECTROSTATIC GENERATOR, $88.50**

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through a tube at low pressures (0.1–2.0 mm.) heated to about 1000° C., it decomposed presumably according to the equation:

$$HN_3 \longrightarrow NH + N_2$$

We found that the imine radical could be frozen out on a surface cooled to −200° C. to give a beautiful blue deposit. This blue material has quite extraordinary properties. It is attracted by a magnet and is stable only below −125° C. At this temperature it quite suddenly changes to a white substance, ammonium azide, $NH_4N_3$, a change which is, of course, irreversible. Notice that ammonium azide is $(NH)_4$.

We have not yet been able to determine the constitution of the blue substance. One is very much circumscribed in working with it since it is stable only below −125° C., has no measurable vapor pressure, and does not seem to be soluble in any solvent. It may be the NH radical loosely coupled with its neighbors, or it may be the much sought di-imide HN=NH, or even a higher polymer. Not much can be settled until X-ray studies at low temperatures are made.

It is a curious fact that the common gas, nitric oxide, is rather analogous to the imine and other radicals that can be frozen out at very low temperatures. Actually nitric oxide is an exceedingly unusual compound in having an odd number of electrons and from this point of view can be considered as being itself a free radical. Indeed, its property of diminishing the speed of many chemical decompositions is usually attributed to its power of combining with chain carrying radicals and thus shortening chains.

At 5000° C. the equilibrium constant of the reaction

$$0.5\ N_2 + 0.5\ O_2 \rightleftarrows NO$$

is approximately 0.5 so that at very high temperatures nitric acid is relatively stable. As the temperature is lowered the nitric oxide becomes less and less stable with respect to nitrogen and oxygen until at room temperature the value of the equilibrium constant is $10^{-17}$. Actually, as is well known, nitric oxide can be prepared by establishing the above equilibrium at very high temperatures and then "freezing" it by cooling the gaseous mixture very rapidly to ordinary temperatures where the rate of decomposition of nitric oxide into nitrogen and oxygen is negligibly slow.

Essentially we have been using this method in our work on the imine radical, and preliminary experiments indicate that this method of studying free radicals has possibilities for preparing a wide variety of molecular fragments in the solid state at low temperatures. ●

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"The young dislike their elders for having fixed minds. But they dislike them even more for being insincere."

—GILBERT HIGHET
*The Art of Teaching*

## Spectrograph in Industry

*(Continued from Page 54)*

are excited in the standard way, on an arc or spark stand, and the spectra duly recorded on the photographic plate. One line from the internal standard and one line from the element whose analysis is sought are selected on the basis of their suitable characteristics. The densities of these lines are determined on a densitometer or microphotometer. The densities are converted to intensities by means of the calibration curve. The log of the ratio of these intensities is plotted against the log of the concentration. This graph is called the working curve. (Figure 5.)

The process is now ready for routine analysis. The samples of unknown concentrations are excited in the same way as the standard samples were. The plate is developed and the densitometer process is repeated. The calibration curve gives the relative intensities for the line pair. Once the ratio of the intensities is known, the working curve gives the concentration of the element whose analysis is desired. Several calculating boards have been designed which greatly speed up this phase of the procedure. The problem of determining the excitation conditions and the working curve is usually a research problem of several months' duration. However, once this has been accomplished the routine analysis is the work of only a half-hour or so.

Photoelectric tubes and electronic circuits are built into some spectrographs to eliminate the photographic process. Then the concentrations may be read directly from dials or clocks. This is the direct reading spectrograph. One such instrument manufactured by Baird Associates can analyze a sample of steel for eight elements within a minute's time. However, once the direct reading spectrograph is rigged for one type of analysis, it may not be used for another type without extensive adjustments. Thus the versatility of the instrument is sacrificed to speed.

Emission spectroscopy may be applied to many fields. The most prominent application is in the analysis of alloys. Many of the industries, producing and using metals of all kinds, use the spectrograph for control analysis. The steel, aluminum, and copper alloy industries are outstanding in this respect.

Soil chemistry and agricultural research consider the spectrograph a powerful tool in the analysis of soils, plants, and animal tissues. This branch of science is continually on the watch for connections between fertilizer and feed in terms of the vigor of plant life and the health of animal life. The better equipped police and crime laboratories have used the spectrograph with great success in the solution of a large number of crimes. These are a few of the more prominent fields of application of the spectrograph.

In brief, wherever there is need of a rapid process for the analysis of many samples of any material for

low concentrations of the metals, emission spectroscopy offers industry a reliable and economical means of achieving these results. This method has become so popular that the number of research papers in the field is yearly filling volumes. The Society of Applied Spectroscopy has a large membership and devotes a good deal of its time each year to papers on various aspects of spectrochemical analysis.

Our attention has been centered on emission spectroscopy in this discussion. Consequently little mention has been made of absorption spectroscopy in the ultra-violet, visible, and infrared regions. Here again is a whole field of analysis for chemical compounds especially, and for molecular structure as well. Then there is the field of Raman spectroscopy which is likewise a powerful tool for the analysis of molecular structure. In all of these branches of spectroscopy the spectrograph we have discussed earlier is the central unit about which the adaptations are built. With the long history behind it and its present wide uses current in industry the spectrograph seems destined for even wider uses in the future. ●

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## Causal Finality in Bacteria

*(Continued from Page 39)*

throwing some light on the function of bacterial enzymes and the economy of their formation. According to his integration of known facts, the role of enzymatic activity in the bacterial cell is four-fold:

1. to release energy for continued existence and division;
2. to provide essential metabolites and nutrilites;
3. to detoxicate metabolic products;
4. to stabilize the internal environment in a variable external one.

In terms of the organism seeking its own good the above four points might read as follows: The bacterium's enzymatic repertoire is directed toward the attainment of that which is good for itself inasmuch as the enzymes formed by it:

1. release energy for the process of assimilation whereby the cell converts substances taken in as food into more protoplasm which in turn results in cell growth and fission;
2. break down nutrients into a form and state suitable for absorption through the cell wall and cell membrane, and subsequently to be resynthesized into essential molecules;
3. prevent self-poisoning by the bacterium's own metabolic waste products;
4. maintain the bacterial protoplasm in equilibrium with factors of the surrounding environment, such as, hydrogen ion concentration, water content, oxygen and carbon dioxide tensions.

That the bacterium is seeking its own good or well being in all these enzymatic reactions can hardly escape one who thoughtfully integrates the facts.

This seeming foresight on the part of the bacterium in seeking to attain what is best for it might appear to point to the possession of a form of intelligence. This view, however, is not at all necessary to explain purposiveness of action in bacteria. All the bacterium's accomplishments are strictly determined by the bacterium reacting according to its nature. Whether or not a given substrate will be utilized by the organism will depend upon whether or not the appropriate enzyme (actual or potential) is included in Nature's gift to the bacterium.

It is in the recognition of the origin of the *given nature*, the origin of the *organization* of the bacterium's cellular components, the origin of its *substantial form*, that one will be able to comprehend clearly the teleological tendencies of bacteria. *Given* nature indicates that the origin is other than the bacterium itself; *organization* points to an organizer; *substantial form*, to a Creator. That these endowments of the living bacterial cell are not the accomplishment of man's head or hand needs no proof. An alternate view is that of a Purposive Mind creating life in the bacterium and endowing it with natural facilities.

With due attention given to considerations like these, the notion of bacteria as bags of chemical devices gives way to the real state of affairs, namely, that bacteria according to their God-given nature use these enzymatic devices to attain their final purpose.

This view is far from being one of defeatism. Rather, it opens the way for the microbiologist to new realms of philosophical and scientific progress, to an understanding of Nature as it actually is since Nature's hands are not tied, and it is not bogged down by the utilitarian aims which animate so much of our present scientific investigations. ●

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## Elementary School Science

*(Continued from Page 56)*

perhaps lose these misconceptions as they are exposed to the processes of pasteurization and homogenization.

Why is it that NSTA is interested, along with industry, in the elementary group? There are several obvious reasons. One is the fact that we are able to contact all children at this level. At this point we are not yet bothered by drop-outs. Science taught through the elementary groups reaches everybody. Furthermore, it is becoming more and more apparent that children must become familiar with the atom and related concepts before 12 or 13 years of age, or the time of entering junior high school. As we progress in our knowledge of science, we become more sensitive as a society to science. We must make more room at the top for further advancement, and this necessitates pushing more and more science into the lower grades. Also, we find that many of our elementary teachers are not trained adequately in science, and while this is no great handicap for the skilful teacher, it is for this group that the packets may be of particular help.

The officers of NSTA are constantly working to increase the help given to the membership. At present the packets are being prepared with a more conscious concern toward the needs of the elementary child. It should not be long before NSTA membership will be a recognized need for teachers in many more of our elementary schools. ●

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"Knowledge consists of experience digested by reason. Reason arranges in some sort of order what has been encountered and observed, either directly or by an imaginative sharing of the experience of others. Education consists, therefore, not only in the training of the reason logically and competently to function but also in the securing of as large and profound and balanced an experience, and none of them can be neglected in education."

—Bernard Iddings Bell
*Crisis in Education*

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—Bernard Iddings Bell
*Crisis in Education*

# Belgians in Chemistry

*(Continued from Page 45)*

analysis of potassium chromate, iodine solutions, iron and tin salts, hydrobromic and hydriodic acids, and alkyl iodides. Crismer's main contribution to chemistry dealt with saponification of fats and oils. He contributed much to our knowledge of the preparation of emulsions, especially for use in pharmaceuticals and is also known for a very efficient distilling column named for him. He died in 1944.

Frederic Swarts[14] became prominent at the turn of the century. He was born in Ixelles in 1866, and later became professor of chemistry at the University of Ghent. He was unique among his contemporaries in that he devoted his time exclusively and singularly to one phase of chemistry, that of organic fluorides. After completion of the classical pioneering of Moissan who discovered fluorine, (around 1900), worthwhile contributions in the next twenty-five years to fluoride chemistry were practically limited to the investigations of Swarts. He did much in laying the foundations for the commercialization of organic fluorides, after 1930, as refrigerants in household devices and air-conditioning equipment. In addition, he studied the additive properties of fluorine to acetylene tetrachloride, the directing influence of the $CF_3$ side chain in aromatic substitution reactions, and gave a critical discussion of experimental data obtained on viscosity, refraction, and dispersion of fluorine compounds. Shortly before his death (1940) he undertook and successfully completed a series of reactions illustrating the stability of the $CF_3$ group.

A survey of the achievements of those whose reputations emanated from Belgian laboratories would be incomplete unless brief consideration is given to those of Belgian birth whose feats were accomplished in foreign countries. Several well-known scientists have migrated to the United States from Belgium, and all have left their marks in the annals of science and technology. These men include Albert Sauveur, Leo Baekeland, and Julius Nieuwland.

Albert Sauveur was born in 1863 at Louvain and was educated at Brussels, Liège, and Massachusetts Institute of Technology. He was the recipient of the honorary Sc.D. degree from many colleges both here and abroad, and received medals and honors of distinction from numerous governments and institutions. He was the founder of the science of metallography in the United States, and did much to improve the microscopic equipment and techniques for the examination of metals. His pioneering in metallurgy and metallography opened the way for many useful developments in the chemical properties and structure of steels. No wonder then it is often claimed that a metallurgical hall of fame would be incomplete without the name of Albert Sauveur.

Leo Hendrik Baekeland[15,16], like Albert Sauveur, was an experimenter whose exploration of scientific frontiers did much to accelerate their advance. He was born in Ghent in 1863, and received his B.S. from the University there in 1882. His early brilliance was shown when he received his doctorate, cum laude, two years later. He remained in Belgium for five more years and became a companion of the then elderly Stas. As first prize winner in a competition among the laureates of the Belgian universities, he came to this country (in 1889) on a travelling fellowship. He decided to remain, and after nine years (1898) became famous through his invention of "Velox" paper for photography. He sold the rights of his discovery to the Eastman Kodak Company, and thus became financially independent.

In looking for a new problem to investigate he decided to re-examine a field which had previously, but not fruitfully, been studied by von Baeyer, Klieberg, and Story. The challenge involved the perfection of synthetic resins through the combination of phenol and formaldehyde. After four years of work (1908), Baekeland's penchant for success was again demonstrated and he called his triumph in synthetic chemistry Bakelite. His method for the application of heat to a resinous material in the presence of an alkali catalyst (which first causes softening and subsequent setting to a hard solid) easily adapted itself to industrial production. The versatility of Bakelite became evident, and today it has become a familiar item. With his discovery, Baekeland earned world-wide recognition, and became the recipient of many honorary degrees and medals from both foreign and American universities and governments.

Father Julius A. Nieuwland[17] was still another well reputed chemist who, although born in Belgium, carried on his work in the United States. However, while both Sauveur and Baekeland were educated in Belgium, and thus were really products of that country, Nieuwland was educated in the United States. He was born in 1878 in Ghent, and in 1899 received his A.B. degree from Notre Dame. In 1904, he was the recipient of the Ph.D. degree from Catholic University, and in 1911 received a Sc.D. from Notre Dame. Father Nieuwland's early interests were divided between chemistry and botany and his work included the synthesis of organic compounds from acetylene, and the taxonomy and nomenclature of higher plants. Even during his undergraduate days at Notre Dame he was already what he liked to call "catalyst minded" when he synthesized acetaldehyde from acetylene using mercurous chloride as a catalyst. In 1904 while yet a young student working on his Ph.D. thesis, he obtained an extremely toxic, blistering substance from a reaction between acetylene and arsenic trichloride in the presence of aluminum trichloride. He recorded his observations privately since he saw no value in the compound. However in later years this rejected compound was identified as beta-chlorovinyldichloroarsine, the extremely toxic war gas, Lewisite. In 1918, Father Nieuwland, using a cuprous chloride ammonium chloride solution as a catalyst, prepared divinyl acetylene, and later monovinyl acetylene. This discovery of the process of acetylene polymerization proved to be one of the long sought keys to the synthesis of synthetic rubbers. For this work he received the Nichols medal in 1935. His death in 1936 culminated a lifetime of continuous studies on hydrocarbons.

To conclude adequately a presentation of men distinguished in chemistry up to and including the early

20th century (albeit superficial it may be) it is well to consider finally Jean Timmermans[18] (1882- ), a physical chemist well known to his contemporaries in the United States. His training included, in addition to the doctorate in chemical sciences under Crismer at Brussels, six to eight industrious years in the laboratories of such other luminaries of the early 1900's as Rothmund (Prague), Young (Dublin), van der Waals (Amsterdam), Guye (Geneva), and Kammerlingh-Onnes (Leyden). In 1919 he became director of the laboratory of physical chemistry at the University of Brussels, and in 1921, director of the Bureau of Physico-Chemical Standards at Brussels. His main efforts have been in the physical characterization of pure organic compounds and in the study of their mixtures including phase relationships under high pressures. He is known also for his books on liquid mixtures, concentrated solutions, physical organic standards, and history of chemistry. Perhaps one of his best contributions has resulted from his intense interest in the establishment of scientific libraries and the organization and dissemination of scientific literature. He deserves rich credit also for his part in the careful preservation of much of the Stas relics and correspondence now deposited in the *Salle Jean Stas* at Brussels.

Consideration of the efforts of modern Belgians is inordinately difficult in a paper in which the emphasis is placed on scientific developments in chemistry. In the early days of science individuals with varied research interests could pioneer in a number of fields which are highly specialized today and which funnel the present day investigations into smaller segments of the whole. Obviously then, it is untenable for a few historians to weigh correctly the relative merits of a spate of contributions in many diverse categories. However, among the many men to whom acknowledgment may be made could be listed Professors W. Mund and M. de Hemptinne at Louvain. The former has worked in radiochemistry while the latter has studied, among other things, the structure of molecules by infra red and Raman spectra and the application of radioisotopes thereto. At Louvain there is also G. Bruylants, a student of Louis Henry, who has done extensive work on spectrographic analysis of organic compounds and on the synthesis of cyclopropane, and to whom the national decennial prize has been recently awarded. Another of Henry's students, L. Breckpot is well known for his publications on the spectrographic analysis of metals.

At Ghent, J. Goubeau, R. Ruyssen, J. Gillis, and F. Govaert comprise a well-known group; whereas at Brussels one should include A. Reychler who was active in the early nineteen hundreds and who wrote one of the first treatises on physical chemistry, O. Dony-Henault of the same generation, and the currently active Miss L. de Brouckère.

At Liège there are L. D'Or, C. Gillet, and, among the recent dead, Victor Henri who although of French extraction finished his career there in a most brilliant fashion. G. Chavanne, also of French birth and recently deceased, was another whose ability and accomplishments have brought a goodly measure of prestige to Brussels. Other names in a long list there might include: Th. De Donder and R. Defay in mathematical physics and thermodynamics of surface tension and adsorption; G. van Lerberghe (killed in combat in 1940); and I. Prigogine who is earning world recognition with his *Theorie Thermodynamique des Phenomenes Irreversibles*. M. Pourbaix at Brussels is also earning repute in the field of electrochemistry of corrosion.* Just as it is necessary to make comparisons among the heavenly bodies in a galaxy from a significant distance in space, it will probably be necessary to wait for the next generation of historians to post the scores and make the proper accreditations to those cited herein as well as to those perhaps erroneously omitted.

To point up the present account, a few statistics pertinent to current developments in Belgium will attest to the vigorous chemical economic activity currently in effect. In industry, chemicals and pharmaceuticals constitute the second largest percentage of the exported goods. Its chief minerals are coal, copper, iron, lead, and zinc, and the government is developing uranium deposits located in the Belgian Congo. About eleven thousand students were in attendance in the Belgian universities in 1937-38. (This figure is probably low if comparison can be made with the American post-war increases in student numbers.) The scientific literature of the country is serviced by a number of significant journals. The more important are: *Bulletin de la Classe des sciences, Académie royale de Belgique; Bulletin des sociétés Chimiques Belges*, formerly, *Bulletin de la société chimique de Belgique;* and, *Annales de la société scientifique de Bruxelles*. Several others of lesser significance also exist. *Chemical and Engineering News*[19] lists, respectively, fifty-eight and forty-four Belgian scientific journals which were abstracted by *Chemical Abstracts* in 1946 and 1947. These constituted 1.3 and 1.6 per cent of the total world scientific literature abstracted in these years.

In summation, a list of Belgian contributors to science and mainly to chemistry is appended (Table I). The impacts made upon the development of chemistry as a whole affected materially the theories of atomic weights, and structure of organic compounds, and analysis. Valuable advances were made by means of the industrially significant soda and plastic processes, and in the fields of organic fluorides and nitriles. The foregoing account has shown, if little else, the international nature of science, in demonstrating the interlacing or superimposition of the creativeness of Belgian scientists on science as a whole. It is illuminating, and sometimes inspirational, to note how many discoveries both theoretical and practical can be credited to a group whose total population is but a small fraction of the world's and which was not established as an independent entity until relatively recently in world history. ●

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## Reproductive Processes

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## Storage Battery

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and straps is lead-calcium instead of lead-antimony, the calcium content being less than 0.1 per cent. At present they are suited only for closely regulated float charge operation, and not for cycle service.

Various additives for the electrolyte, usually magnesium sulphate (Epsom salt), sodium sulphate or mixtures thereof, have been marketed frequently and advertised as capable of prolonging battery life and revitalizing badly sulphated plates. So far there has apparently not been any adequate demonstration that they are of any value, according to the Bureau of Standards Tests and Reports, and some are actually injurious. All of them should be avoided.

The life of storage batteries varies over a wide range, depending on construction, care and operating conditions. It may vary from a single or a few discharges to "stand-by" service with recorded lives up to as much as 30 years.

The operating temperature of a battery materially affects its output. In the lead-acid type of cells the loss in capacity is reasonably proportional to the temperature drop, while for the nickel-iron type of battery there is a critical temperature point below which the capacity is greatly reduced, but above which the capacity is not affected as much by temperature variations as is the lead-acid type. The critical temperature varies with the discharge rate.

The general care which a storage battery receives is an important factor in its life and satisfactory operation. There are few places in this country where the normal water supply is not satisfactory for ordinary replacement requirements for lead-acid type batteries, but distilled water is specified for the nickel-iron types. Periodic gravity readings on the lead-acid types give a good indication of the state of charge and are a big help in preventing battery failures. Cleanliness is also important with any battery, and the manufacturers are always glad to furnish instructions for their batteries in specific types of service. ●

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